

## CHAPTER 4

# RESIDENTIAL ENERGY

### PART I—ENERGY CONSERVATION

#### SECTION 401 SCOPE

**401.1 General.** The provisions of this chapter regulate the exterior envelope, as well as, the design, construction and selection of heating, ventilating and air-conditioning systems, lighting and piping insulation, required for the purpose of effective conservation of energy within a building or structure governed by this code.

All conditioned spaces within residential buildings shall comply with Table 401.1(1) and one additional measure from Table 401.1(2).

**401.2 Application to existing buildings.** Alteration and repairs, historic buildings, and change of use or occupancy to buildings, structures or portions thereof shall comply with the requirements in Sections 401.2.1 through 401.2.3.

**401.2.1 Alteration and repair.** Alterations and repairs affecting energy conservation measures shall conform to the requirements specified in this chapter.

Alterations or repairs which affect components of existing conditioned spaces regulated in this chapter shall comply with this chapter.

**Exception:** The minimum component requirements as specified in Note d of Table 404.1(2) may be used to the maximum extent practical.

**401.2.2 Historic buildings.** The building official may modify the specific requirements of this chapter for historic buildings and require in lieu thereof alternative requirements that will result in a reasonable degree of energy efficiency. This modification may be allowed for those buildings specifically designated as historically significant by the state historic preservation office(r) or by official action the local government.

**401.2.3 Change of occupancy or use.** Definition of "Change of use" for purposes of Section 401.2.3 is a change of use in an existing residential building and shall include any of the following; any unconditioned spaces such as an attached garage, basement, porch, or canopy that are to become conditioned spaces; any unconditioned, inhabitable space that is to become conditioned space, such as a large attic.

**401.2.3.1 Change of use.** A building that changes use, without any changes to the components regulated in this chapter, are required to comply with the minimum component requirements as specified in Note d of Table 404.1(1) to the greatest extent practical.

**401.2.3.2 Change of occupancy.** Alteration and repair of nonresidential buildings, such as a small church or school, that change the occupancy to residential may use the minimum component requirements as specified in Note d of Table 404.1(2) to the greatest extent practical.

**Exception:** The minimum component requirements may be disregarded when thermal performance calculations are completed for change of use to Group R occupancy.

**401.3 Additions.** Additions to existing buildings or structures may be made without making the entire building or structure comply, if the new additions comply with the requirements of this chapter.

**401.4 Information on plans and specifications.** Plans and specifications shall show in sufficient detail all pertinent data and features of the building and the equipment and systems as herein governed, including, but not limited to, exterior envelope component materials; *R*-values of insulating materials; HVAC equipment efficiency performance and system controls, lighting and other pertinent data to indicate conformance to the requirements of this chapter.

#### SECTION 402 DEFINITIONS

**402.1 Definitions.** See Section 202 of this code.

#### SECTION 403 ALTERNATIVE SYSTEMS

Alternative designs may be approved by the building official when it can be demonstrated that the proposed annual energy consumption will not exceed that of a similar building with similar forms of energy requirements designed in accordance with the provisions of this chapter. The only allowed trade-offs in this analysis are between building envelope components.

Proposed alternative designs submitted as requests for exception to the standard design criteria must be accompanied by an energy analysis prepared in accordance with criteria specified in Part II, Alternative Systems Analysis.

**403.1 Design parameters.** For calculations under this section, the following design parameters shall apply:

The outside temperature shall be taken from the 99 percent winter temperature values and the 1 percent summer temperature values listed in ASHRAE *Handbook of Fundamentals*. For areas not listed, the designer should obtain the most reliable design temperatures available. Selected values are subject to approval of the building official.

**TABLE 401.1(1)  
PRESCRIPTIVE ENVELOPE REQUIREMENTS<sup>a</sup>**

BUILDING COMPONENT	STANDARD BASE CASE		LOG HOMES ONLY	
	Required Performance	Equivalent Value <sup>b</sup>	Required Performance	Equivalent Value <sup>b</sup>
Wall insulation—above grade	U-0.060	R-21 <sup>c</sup>	Note d	Note d
Wall insulation—below grade <sup>e</sup>	F-0.565	R-15	F-0.565	R-15
Flat ceilings <sup>f</sup>	U-0.031	R-38	U-0.025	R-49
Vaulted ceilings <sup>g</sup>	U-0.042	R-38 <sup>g</sup>	U-0.027	R-38A <sup>h</sup>
Underfloors	U-0.028	R-30	U-0.028	R-30
Slab edge perimeter	F-0.520	R-15	F-0.520	R-15
Heated slab interior <sup>i</sup>	n/a	R-10	n/a	R-10
Windows <sup>j</sup>	U-0.35	U-0.35	U-0.35	U-0.35
Window area limitation <sup>k</sup>	n/a	n/a	n/a	n/a
Skylights <sup>l</sup>	U-0.60	U-0.60	U-0.60	U-0.60
Exterior doors <sup>m</sup>	U-0.20	U-0.20	U-0.54	U-0.54
Exterior doors w/ > 2.5 ft <sup>2</sup> glazing <sup>n</sup>	U-0.40	U-0.40	U-0.40	U-0.40
Forced air duct insulation	n/a	R-8	n/a	R-8

For SI: 1 square foot = 0.0929m<sup>2</sup>.

- a. As allowed in Section 404.1, thermal performance of a component may be adjusted provided that overall heat loss does not exceed the total resulting from conformance to the required *U*-value standards. Calculations to document equivalent heat loss shall be performed using the procedure and approved *U*-values contained in Table 404.1(1).
- b. *R*-values used in this table are nominal, for the insulation only in standard wood framed construction and not for the entire assembly.
- c. Wall insulation requirements apply to all exterior wood framed, concrete or masonry walls that are above grade. This includes cripple walls and rim joist areas. R-19 Advanced Frame or 2 x 4 wall with rigid insulation may be substituted if total nominal insulation *R*-value is 18.5 or greater.
- d. The wall component shall be a minimum solid log or timber wall thickness of 3.5 inches (90 mm).
- e. Below-grade wood, concrete or masonry walls include all walls that are below grade and does not include those portions of such wall that extend more than 24 inches above grade.
- f. Insulation levels for ceilings that have limited attic/rafter depth such as dormers, bay windows or similar architectural features totaling not more than 150 square feet (13.9 m<sup>2</sup>) in area may be reduced to not less than R-21. When reduced, the cavity shall be filled (except for required ventilation spaces).
- g. The maximum vaulted ceiling surface area shall not be greater than 50 percent of the total heated space floor area unless area has a *U*-factor no greater than U-0.031. The *U*-factor of 0.042 is representative of a vaulted scissor truss. A 10-inch (254 mm) deep rafter vaulted ceiling with R-30 insulation is U-0.033 and complies with this requirement, not to exceed 50 percent of the total heated space floor area.
- h. A = advanced frame construction, which shall provide full required insulating value to the outside of exterior walls.
- i. Heated slab interior applies to concrete slab floors (both on and below grade) that incorporate a radiant heating system within the slab. Insulation shall be installed underneath the entire slab.
- j. Sliding glass doors shall comply with window performance requirements. Windows exempt from testing in accordance with Section 411.2, Item 3 shall comply with window performance requirements if constructed with thermal break aluminum or wood, or vinyl, or fiberglass frames and double-pane glazing with low-emissivity coatings of 0.10 or less.
- k. Reduced window area may not be used as a trade-off criterion for thermal performance of any component.
- l. Skylight area installed at 2 percent or less of total heated space floor area shall be deemed to satisfy this requirement with vinyl, wood, or thermally broken aluminum frames and double-pane glazing with low-emissivity coatings. Skylight *U*-factor is tested in the 20 degree (0.35 rad) overhead plane per NFRC standards.
- m. A maximum of 28 square feet (2.6 m<sup>2</sup>) of exterior door area per dwelling unit can have a *U*-factor of 0.54 or less.
- n. Glazing that is either double pane with low-e coating on one surface, or triple pane shall be deemed to comply with this U-0.40 requirement.

**TABLE 401.1(2)**  
**ADDITIONAL MEASURES (select one)<sup>a</sup>**

MEASURE	
1	High efficiency HVAC system: Gas-fired furnace or boiler with minimum AFUE of 90% <sup>a</sup> , or Air-source heat pump with minimum HSPF of 8.5, or Closed-loop ground source heat pump with minimum COP of 3.0
2	High efficiency duct sealing: Certified performance tested duct systems <sup>b</sup> or All ducts and air handler are contained within building envelope <sup>a</sup>
3	High efficiency building envelope: Replace corresponding Table 401.1(1) components with all of the following: Wall insulation—above grade – U-0.047/R-24, and Vaulted ceilings – U-0.033/R-30A <sup>c,d</sup> , and Flat ceilings – U-0.025/R-49, and Windows – U-0.32
4	Zonal electric, ductless furnace or ductless heat pumps: 75 percent of lamps in permanently installed lighting fixtures as CFL or linear fluorescent or a min efficacy of 40 lumens per watt, or Windows – U-0.32, or Flat ceilings – U-0.025/R-49 and vaulted ceilings – U-0.033/R-30A, or Exterior walls – U-0.047/R24
5	High efficiency ceilings & windows/lighting: Replace corresponding Table 401.1(1) components with all of the following: Vaulted ceilings – U-0.033/R-30A <sup>c,d</sup> , and Flat ceilings – U-0.025/R-49, and Windows – U-0.32, and 75 percent of lamps in permanently installed lighting fixtures as CFL or linear fluorescent or a min efficacy of 40 lumens per watt
6	High efficiency ceilings & windows/water heating: Replace corresponding Table 401.1(1) components with all of the following: Vaulted ceilings – U-0.033 / R-30A <sup>c,d</sup> , and Flat ceilings – U-0.025 / R-49, and Windows – U-0.32, and Natural gas/propane, on-demand water heating with min EF of 0.80
7	High efficiency water heating/lighting: Natural gas/propane, on-demand water heating with min EF of 0.80, and 75 percent of lamps in permanently installed lighting fixtures as CFL or linear fluorescent or a min. efficacy of 40 lumens per watt
8	Solar photovoltaic: Minimum 1 Watt/sq ft. conditioned floor space <sup>e</sup>
9	Solar water heating: Minimum of 40 ft <sup>2</sup> of gross collector area <sup>f</sup>

For SI: 1 square foot = 0.0929m<sup>2</sup>.

- a. Furnaces located within the building envelope shall have sealed combustion air installed. Combustion air shall be ducted directly from the outdoors.
- b. Documentation of performance tested ductwork shall be submitted to the building official upon completion of work. This work shall be performed by a contractor that is certified by the Oregon Department of Energy's (ODOE) Residential Energy Tax Credit program and documentation shall be provided that work demonstrates conformance to ODOE duct performance standards.
- c. A = advanced frame construction, which shall provide full required ceiling insulation value to the outside of exterior walls.
- d. The maximum vaulted ceiling surface area shall not be greater than 50 percent of the total heated space floor area unless vaulted area has a U-factor no greater than U-0.026.
- e. Solar electric system size shall include documentation indicating that total solar resource fraction is not less than 75 percent.
- f. Solar water heating panels shall be Solar Rating and Certification Corporation (SRCC) Standard OG-300 certified and labeled, with documentation indicating that total solar resource fraction is not less than 75 percent.

**SECTION 404  
EXTERIOR ENVELOPE REQUIREMENTS**

**404.1 General.** This section provides minimum requirements for exterior envelope construction.

Exterior building envelope shall comply with Table 401.1(1) or may be demonstrated using Table 404.1(1). The requirements specified in Table 401.1(2) shall apply to both Tables 401.1(1) and 404.1(1).

Buildings designed to incorporate passive solar elements may use Table 404.1(1) to demonstrate building envelope requirements of this code, in addition to requirements specified in Table 401.1(2)

**404.2 Insulation materials.** Insulation materials shall be installed per manufacturer’s listing and specifications and this section. Insulation R-values shall be specified as required in 16 CFR Ch. I (1-1-91 Edition) Part 460—Labeling and Advertising of Home Insulation. Some general requirements for insulation are mentioned in the following subsections:

**404.2.1 Loose-fill insulation.** Blown, poured and spray-on type insulation complying with Section R316 of the *Oregon Residential Specialty Code* may be used in attic spaces where roof slope is 4 units vertical in 12 units horizontal (33.3 percent slope) or greater, and there is at least 44 inches (1118 mm) of headroom at the roof ridge. (Clear headroom is defined as the distance from the top of the bottom chord of the truss or ceiling joists to the underside of the roof sheathing.) Adequate baffling of the vent opening shall be provided so as to deflect the incoming air above the surface of the blown or poured insulation. Baffles shall be of weather-resistant, rigid material capable of retaining the insulation and shall be in place at the time of framing inspection.

**404.2.2 Batt-type insulation.** Batt-type insulation shall be installed flush against the warm side of the cavity insofar as practicable.

**404.2.3 Insulation protection.** Insulation exposed to the exterior shall be protected from physical and solar damage.

**TABLE 404.1(1)  
RESIDENTIAL THERMAL PERFORMANCE CALCULATIONS**

BUILDING COMPONENTS <sup>b</sup>	STANDARD BASE CASE <sup>a</sup>			PROPOSED ALTERNATIVE			
	Areas <sup>c</sup>	U-factor	Areas x U	R-value <sup>d</sup>	Areas <sup>c</sup>	U-factor <sup>e</sup>	Areas x U
Flat ceilings		0.031					
Vaulted ceilings <sup>f</sup>		0.042					
Conventional wood-framed walls		0.060					
Underfloor		0.028					
Slab edge		(perimeter ft. =) F = 0.52 <sup>g</sup>					
Windows		0.35					
Skylights < 2% <sup>h</sup>		0.75					
Skylights > 2% <sup>h</sup>		0.60					
Exterior doors <sup>i</sup>		0.20					
Doors with > 2.5 ft <sup>2</sup> glazing		0.40					
		<b>CODE UA =</b>				<b>PROPOSED UA<sup>j</sup> =</b>	

For SI: 1 square foot = 0.0929 m<sup>2</sup>, 1 Btu/(hr · ft<sup>2</sup> · °F) = 5.6782 W/m<sup>2</sup> · K.

a. Base path 1 represents standard base case from Table 401.1(1).

b. Performance trade-offs are limited to those listed in column 1. Heat plant efficiency, duct insulation levels, passive and active solar heating, air infiltration and similar measures including those not regulated by code may not be considered in this method of calculation.

c. Areas from plan take-offs. All areas must be the same for both standard base case and proposed alternate. The vaulted ceiling surface area for standard base case must be the actual surface area from the plan take-off not to exceed 50 percent of the total heated space floor area. Any areas in excess of 50 percent for base case must be entered at U-0.031 (R-38) with “Flat Ceilings” area.

d. Minimum Component Requirements: Walls R-15; Floors R-21; Flat Ceilings R-38; Vaults R-21; Below-Grade Wood, Concrete or Masonry Walls R-15; Slab Edge R-10; Duct Insulation R-8. R-values used in this table are nominal, for the insulation only and not for the entire assembly. Window and skylight U-values shall not exceed 0.65 (CL65). Door U-values shall not exceed 0.54 (Nominal R-2). A maximum of 28 square feet (2.6 m<sup>2</sup>) of exterior door area per dwelling unit can have a U-factor of 0.54 or less and shall not be included in calculations.

e. U-values for wood frame ceilings, walls and floor assemblies shall be as specified in Table 404.1(2). U-values for other assemblies, which include steel framing, brick or other masonry, stucco, etc., shall be calculated using standard ASHRAE procedures.

f. Vaulted area, unless insulated to R-38, U-0.031, may not exceed 50 percent of the total heated space floor area.

g. F = The heat loss coefficient, Btu/hr./ft.<sup>2</sup>/°F per foot of perimeter.

h. Whenever skylight area for proposed alternative exceeds 2 percent of the total heated space floor area, enter 2 percent of area under standard base case at U-0.75 then the remaining area under Standard Base Case at U-0.60. For proposed alternative skylights, enter the actual skylight area and U-factor of those to be installed in residence.

i. A maximum of 28 square feet (2.6 m<sup>2</sup>) of exterior door area per dwelling unit can have a U-factor of 0.54 or less. Default U-factor for an unglazed wood door is 0.54.

j. Proposed UA must be less than or equal to Code UA.

**TABLE 404.1(2)**  
**APPROVED DEFAULT U-FACTORS**

FLAT CEILINGS <sup>a</sup>			EXTERIOR WALLS <sup>a</sup>			
Insulation	Type	U-Factor	Insulation	Insulation Sheathing	Framing	U-Factor
R-38	Conventional framing	0.031	R-15	0	Conventional framing	0.080
R-38	= > 8/12 roof pitch	0.028	R-15	0	Intermediate framing <sup>b</sup>	0.075
R-38	Advance framing <sup>c</sup>	0.026	R-19	0	Conventional framing	0.065
R-49	Conventional framing	0.025	R-19	0	Intermediate framing <sup>b</sup>	0.063
R-49	= > 8/12 roof pitch	0.024	R-19	0	Advance framing <sup>d</sup>	0.061
R-49	Advance framing <sup>c</sup>	0.020				
VAULTED CEILINGS <sup>a</sup>						
Insulation	Type	U-Factor	R-21	0	Conventional framing	0.060
R-21	Rafter framing	0.047	R-21	0	Intermediate framing <sup>b</sup>	0.058
R-30	Rafter framing	0.033	R-21	0	Advance framing <sup>d</sup>	0.055
R-38	Rafter framing	0.027	R-11	3.5 <sup>e</sup>	Conventional framing	0.069
R-21	Scissors truss	0.055	R-11	5 <sup>e</sup>	Conventional framing	0.063
R-30	Scissors truss	0.046	R-11	7 <sup>e</sup>	Conventional framing	0.055
R-38	Scissors truss	0.042	R-11	3.5 <sup>e</sup>	Advance framing <sup>d</sup>	0.067
R-49	Scissors truss	0.039	R-11	5 <sup>e</sup>	Advance framing <sup>d</sup>	0.061
R-30	Advance scissors truss <sup>c</sup>	0.032	R-11	7 <sup>e</sup>	Advance framing <sup>d</sup>	0.054
R-38	Advance scissors truss <sup>c</sup>	0.026	R-13	3.5 <sup>e</sup>	Conventional framing	0.064
R-49	Advance scissors truss <sup>c</sup>	0.020	R-13	5 <sup>e</sup>	Conventional framing	0.058
EPS FOAM CORE PANEL VAULTED CEILINGS			R-13	7 <sup>e</sup>	Conventional framing	0.052
Insulation	Type	U-Factor	R-13	3.5 <sup>e</sup>	Advance framing <sup>d</sup>	0.062
R-29	8-1/4" EPS foam core panel	0.037	R-13	5 <sup>e</sup>	Advance framing <sup>d</sup>	0.056
R-37	10-1/4" EPS foam core panel	0.030	R-13	7 <sup>e</sup>	Advance framing <sup>d</sup>	0.050
R-44	12-1/4" EPS foam core panel	0.025				
FLOORS <sup>a</sup>			R-15	3.5 <sup>e</sup>	Conventional framing	0.060
Insulation	Type	U-Factor	R-15	5 <sup>e</sup>	Conventional framing	0.055
R-21	Underfloor	0.035	R-15	7 <sup>e</sup>	Conventional framing	0.049
R-25	Underfloor	0.032	R-15	3.5 <sup>e</sup>	Advance framing <sup>d</sup>	0.057
R-30	Underfloor	0.028	R-15	5 <sup>e</sup>	Advance framing <sup>d</sup>	0.052
			R-15	7 <sup>e</sup>	Advance framing <sup>d</sup>	0.047
SLAB-ON-GRADE						
Insulation	Type	F-Factor <sup>f</sup>	R-19	3.5 <sup>e</sup>	Conventional framing	0.052
R-10	Slab edge	0.54	R-19	5 <sup>e</sup>	Conventional framing	0.047
R-15	Slab edge	0.52	R-19	7 <sup>e</sup>	Conventional framing	0.043
EPS FOAM CORE PANEL EXTERIOR WALLS			R-19	3.5 <sup>e</sup>	Advance framing <sup>d</sup>	0.049
Insulation	Type	U-Factor	R-19	5 <sup>e</sup>	Advance framing <sup>d</sup>	0.045
R-14.88	4-1/4" EPS foam core panel	0.065	R-19	7 <sup>e</sup>	Advance framing <sup>d</sup>	0.041
R-22.58	6-1/4" EPS foam core panel	0.045				
R-29.31	8-1/4" EPS foam core panel	0.035	R-21	5 <sup>e</sup>	Conventional framing	0.044
			R-21	7 <sup>e</sup>	Conventional framing	0.040
			R-21	3.5 <sup>e</sup>	Advance framing <sup>d</sup>	0.044
			R-21	5 <sup>e</sup>	Advance framing <sup>d</sup>	0.042
			R-21	7 <sup>e</sup>	Advance framing <sup>d</sup>	0.038

For SI: 1 inch = 25.4 mm, 1 Btu/(hr · ft<sup>2</sup> · °F) = 5.6782 W/m<sup>2</sup> · K.

- U-factors are for wood frame construction. U-factors for other assemblies which include steel framing, brick or other masonry, stucco, etc., shall be calculated using standard ASHRAE procedures.
- Intermediate framing consists of wall studs placed at a minimum 16 inches on-center with insulated headers. Voids in headers shall be insulated with rigid insulation having a minimum R-value of 4 per one-inch (w/m<sup>3</sup>-k) thickness.
- Advanced framing construction for ceilings as defined in Section 404.6
- Advanced framing construction for walls as defined in Section 404.5
- Insulation sheathing shall be rigid insulation material, installed continuously over entire exterior or interior of wall (excluding partition walls).
- F-Factor is heat loss coefficient in Btu/hr/°F per lineal foot of concrete slab perimeter.

**404.2.4 Clearances.** Recessed light fixtures shall not be installed in cavities intended to be insulated.

**Exception:** Fixtures designed and labeled as suitable for being installed in direct contact with insulation; i.e., insulation coverage (IC) rated.

Thermal insulation shall not be installed within 3 inches (76 mm) of any metal chimney or gas vent that is not listed for insulation clearances.

Thermal insulation shall not be installed in a manner that would obstruct openings required for attic ventilation.

A permanent sleeve of fine wire mesh screen, sheet metal or other noncombustible material shall be installed to maintain the required clearances.

Cellulose insulation shall conform to Interim Safety Standard for Cellulose Insulation (16 CFR Part 1209) issued by the Consumer Product Safety Commission July 6, 1979 (44FR 39938). For other insulation, see Section R320 of the *Residential Code*. Foam plastic shall be as specified in Section R318 of the *Residential Code*.

**404.2.5 Below grade exterior insulation.** Below grade exterior insulation shall meet the following conditions:

1. The insulation shall be a materials that is approved for below-grade applications in wet environments
2. Insulation shall be installed from the top of the footing to the top of the concrete basement wall.
3. Insulation shall be adequately protected from the elements (ultraviolet and mechanical) per manufacturer's specifications.
4. The top of the insulation shall be installed in a manner to allow water run-off and prevent pooling.

**404.2.6 Recessed lighting fixtures.** Recessed lighting fixtures installed within the building envelope shall meet one of the following requirements.

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity, and the annular space between the ceiling cutout and lighting fixture shall be sealed.
2. Type IC rated in accordance with ASTM E283, with no more than 2.0 cubic feet per minute (cfm) (0.944 L/s) air movement from the conditioned space to the ceiling cavity at 1.57 psi pressure (75 Pa) difference and shall be labeled and the annular space between the ceiling cutout and lighting fixture shall be sealed.
3. Type IC rated installed inside a sealed box constructed from a minimum 0.5-inch-thick (12.7 mm) gypsum wallboard or constructed from a preformed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose.

**404.3 Exterior doors.** Doors shall be tested according to the requirements of Section 404.4. When calculating the energy

performance of the exterior envelope, the area of doors shall be the actual unit size.

**Exceptions:**

1. Unglazed doors that are not tested according to the requirements of Section 404.4 shall be assigned a default  $U$ -value of 0.54.
2. Sliding glass doors and swinging glass doors shall meet the specifications for windows and shall be treated as such.
3. Doors that incorporate glazed areas more than 2.5 square feet (0.23 m<sup>2</sup>) in area shall be considered exterior doors with greater than or equal to 2.5 square feet (0.23 m<sup>2</sup>) glazing.

Doors shall meet the air leakage requirements of Section 404.8.

**404.4 Windows.** All windows installed in Oregon shall meet the requirements of Part III, Fenestration Standard.

1. Decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area is exempt from thermal performance requirements and do not need to be included in Table 404.1(1) thermal performance calculations.
2. Glass block assemblies may use a  $U$ -factor of 0.51.
3. The  $U$ -factor for windows may be a weighted average of total window area when all other building envelope measures are in compliance with performance requirements specified in this code. This calculation shall be provided to the building official and the windows that are less than required for prescriptive compliance shall be identified on the plans.

**404.4.1 Thermal performance labeling.** Labels shall be either:

1. National Fenestration Rating Council (NFRC) certified product; or
2. State-approved for windows produced in low volume.

All windows shall have labeling:

1. That is imprinted, not handwritten,
2. Facing the interior of the room,
3. Attached to the window until the building inspector inspects and verifies the labeling, and
4. List the  $U$ -factor.

**Exceptions:**

1. Labeling is not required for decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area.
2. Portions of labels for windows produced in low volume may be handwritten.

**404.4.2 Combined products.** When different window types are combined, mullled together by the manufacturer or manufactured to fit a framed rough opening, a single label may be used.

**Exception:** A solarium shall have one label providing a description of each of the glazed surfaces, such as the front, overhead and each side.

**404.4.3 Air leakage requirements.** Windows shall comply with the air leakage requirements of Section 404.8.

**Exception:** Site-built windows.

**404.4.4 Alterations.** New windows shall have a maximum *U*-factor of 0.40.

**Exceptions:**

1. Decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area may be exempt from thermal performance requirements and Table 404.1(1) calculations.
2. Where necessary to retain architectural consistency with remaining windows in the building, new windows shall have a maximum *U*-value of 0.65.

**404.5 Walls.**

**404.5.1 Advanced framing for walls.** Advanced framing for walls is an optional construction method. Advanced framing, when used to qualify a design under the requirements of Section 404.1(1), shall meet the following requirements:

1. **Walls.** Walls shall be framed with 2X studs at 24 inches (610 mm) on center and shall include the following, as detailed in Items 2 and 3.
2. **Corners and intersections.** Exterior wall and ceiling corners shall be fully insulated through the use of three-stud corners configured to allow full insulation into the corner, or two-stud corners and drywall backup clips or other approved technique. Intersections of interior partition walls with exterior walls shall be fully insulated through the use of single backer boards, midheight blocking with drywall clips or other approved technique.
3. **Headers.** Voids in headers 1 inch (25.4 mm) or greater in thickness shall be insulated with rigid insulation that has a value of R-4 per 1 inch (25.4 mm) or greater. Nonstructural headers (such as in gable end walls) can be eliminated and replaced with insulation to achieve equivalent levels as the surrounding area.

**404.5.2 Intermediate framing for walls.** Intermediate framing for walls is an optional construction method. Intermediate framing, when used to achieve improved wall performance under the requirements of Table 404.1(2), shall meet the following requirements:

1. **Walls.** Walls shall be framed with 2X studs at 16 inches (610 mm) on center and shall include the following, as detailed in Items 2 and 3.
2. **Corners and intersections.** Exterior wall and ceiling corners shall be fully insulated through the use of

three-stud corners configured to allow full insulation into the corner, or two-stud corners and drywall backup clips or other approved technique. Intersections of interior partition walls with exterior walls shall be fully insulated through the use of single backer boards, midheight blocking with drywall clips or other approved technique.

3. **Headers.** Voids in headers 1 inch (25.4 mm) or greater in thickness shall be insulated with rigid insulation that has a value of R-4 or greater per 1 inch (25.4 mm) thickness. Nonstructural headers (such as in gable end walls) can be eliminated and replaced with insulation to achieve equivalent levels as the surrounding area.

**404.5.3 Below-grade walls.** Walls enclosing heated spaces below grade shall be insulated from the bottom of the above-grade sub-floor downward to the top of the below-grade finished floor.

**404.6 Roof/ceiling: Advanced framing for ceilings.** Advanced framing for ceilings is an optional construction method. Advanced framing, when used to qualify a design under the requirements of Section 404.1, shall meet the following requirements:

Framing techniques shall be used in attics and ceilings to provide full insulating value to the outside of exterior walls. This may be accomplished through the use of extra-depth or oversized trusses, double rafters, special insulation components installed at the edge of the wall, or other approved combinations of framing and insulation. The entire surface of the exterior ceiling shall be insulated to the required value including attic hatches, structural members, electrical fixtures (where allowed by the code) and plumbing penetrations.

**404.7 Slab-on-grade floors.** For slab-on-grade floors, the perimeter of the floor shall be insulated.

The insulation shall extend downward from the top of the slab for a minimum of 24 inches (610 mm) or downward to the bottom of the slab, then horizontally beneath the slab for a minimum total distance of 24 inches (610 mm).

**Exception:** For monolithic slabs, the insulation shall extend downward from the top of the slab to the bottom of the thickened edge.

**404.7.1 Slab-on-grade floors with hydronic heat.** For slab-on-grade floors that incorporate hydronic heating, in addition to perimeter insulation, the entire underside of slab shall be insulated to R-10.

**404.8 Air leakage.** The requirements of this subsection shall apply only to those locations separating outdoor ambient conditions from interior spaces that are heated or mechanically cooled and are not applicable to separation of interior spaces from each other. Compliance with the criteria for air leakage shall be determined by tests based on applicable engineering principles.

**404.8.1 Acceptance criteria.** Where specified, compliance with air infiltration rates for all exterior windows, swinging doors and sliding glass doors shall be certified using ASTM E 283 "Standard Test Methods for Rate of Air Leakage

through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen.” Tests shall be conducted at a differential pressure of 1.57 pounds per square foot (75 Pa) [equivalent to 25 mph (40 km/h) wind condition].

1. Windows — 0.37 cubic feet per minute (cfm) per foot (0.17 L/s per m) of sash crack.
2. Swinging doors — 0.37 cfm per square foot (0.17 L/s per m<sup>2</sup>) of door area.
3. Sliding doors — 0.37 cfm per square foot (0.17 L/s per m<sup>2</sup>) of door area.

**404.8.2 Sealing required.** Exterior joints around windows and door frames; between wall cavities and window or door frames, between wall and foundation; between wall and roof; between wall panels; at penetrations or utility services through walls; floors and roofs and all other openings in the exterior envelope shall be sealed in a manner approved by the building official.

**404.9 Moisture control.** To ensure the effectiveness of insulation materials and reduce the hazard of decay and other degradation due to condensation within the structure, moisture-control measures shall be included in all buildings and structures or portions thereof regulated by this chapter.

**404.9.1 Vapor retarders.** A one-perm, dry cup rating vapor retarder shall be installed on the warm side (in winter) of all insulation.

**Exceptions:**

1. When insulation is installed in ceilings inside an existing structure and ventilation is provided as specified in Section R806 of the *Residential Code*, a vapor retarder need not be installed.
2. Below grade walls are not required to have a vapor retarder.
3. Slab-on-grade floors need not have a warm-side vapor retarder.

**404.9.2 Ground cover.** A ground cover shall be installed in the crawl space for both new and existing buildings when insulation is installed. Ground cover shall be 6-mil (0.15 mm) black polyethylene or other approved material of equivalent perm rating. Ground cover shall be lapped 12 inches (305 mm) at all joints and cover the entire surface area extending full width and length of the crawl space and turn 12 inches (305 mm) up the foundation wall. Ground cover of 6-mil (0.15 mm) polyethylene or an approved equal (that is as durable) shall be installed on the ground beneath concrete floor slabs located in conditioned spaces.

## SECTION 405 HEATING, VENTILATING AND AIR-CONDITIONING SYSTEMS

**405.1 General.** This section provides minimum requirements for heating, ventilating and air-conditioning systems.

**405.2 Insulation of ducts.** All new duct systems, or new portions thereof, exposed to unconditioned spaces shall be insulated according to Table 401.1(1).

**Exception:** The replacement or addition of a furnace, air conditioner or heat pump shall not require existing ducts to be insulated to current code.

**405.3 HVAC controls.** All heating, ventilating and air-conditioning systems shall be provided controls as specified herein.

**405.3.1 Temperature.** Each heating, ventilating and air-conditioning system shall be provided with at least one thermostat for the regulation of temperature. Each thermostat shall be capable of being set from 55°F to 75°F (13°C to 24°C) where used to control heating only and from 70°F to 85°F (21°C to 29°C) where used to control cooling only. Where used to control both heating and cooling, it shall be capable of being set from 55°F to 85°F (13°C to 29°C) and shall be capable of operating the system heating and cooling in sequence. It shall be capable of providing a temperature range of at least 5°F (-15°C) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

**405.3.2 Humidity.** If a heating, ventilating and air-conditioning system is equipped with a means for adding moisture to maintain specific selected relative humidity in spaces or zones, a humidistat shall be provided. This device shall be capable of being set to prevent new energy from being used to produce space relative humidity above 30 percent. Where a humidistat is used in a heating, ventilating and air-conditioning system for controlling moisture removal to maintain specific selected relative humidity in spaces or zones, it shall be capable of being set to prevent new energy from being used to produce a space-relative humidity below 60 percent.

**405.3.3 Temperature zoning.** Each separate heating, ventilating and air-conditioning system shall be provided at least one thermostat for regulation of space temperature. In addition, a readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating or cooling input to each zone or floor, excluding unheated or noncooled basements and garages.

**405.3.4 Setback and shutoff.** The thermostat, or an alternate means such as switch or clock, shall provide a readily accessible manual or automatic means for reducing the energy required for heating and cooling during periods of nonuse or reduced need.

**Exceptions:**

1. Where it can be shown that setback or shutdown will not result in a decrease in overall building energy.
2. Equipment with full load demand of 2 kilowatt (6.826 Btu/h) or less may be controlled by readily accessible off-hour controls.

Lowering thermostat set points to reduce energy consumption of heating system shall not cause energy to be expended to reach the reduced setting.

**405.3.4.1 Heat pump controls.** All heat pump system thermostats shall be capable of manual setback and limiting the use of supplemental heat during warm-up periods.

**405.3.4.1.1 Outdoor thermostat required.** The cut-on temperature for the compression heating shall be higher than the cut-on temperature for the supplementary heat, and the cut-off temperature for the compression heating shall be higher than the cut-off temperature for the supplementary heat.

**405.4 Outside combustion air.** See Section R1006 of the *Residential Code* for required outside combustion air for masonry fireplaces, factory-built fireplace(s) and factory-built stoves.

#### 405.5 Equipment performance requirements.

**405.5.1 Heat pumps.** Single phase, air-cooled split and packaged system heat pumps of less than 65,000 Btu/h (19 052W) capacity shall have a heating seasonal performance factor (HSPF) of not less than 7.7 and seasonal energy efficiency ratio (SEER) of not less than 13.

**405.5.2 Air conditioners.** Single phase, air-cooled split and packaged system air conditioners of less than 65,000 Btu/hr capacity shall have a SEER of not less than 13.0.

#### 405.5.3 Furnaces.

**405.5.3.1 Oil-fired furnaces.** Oil-fired furnaces shall have an annual fuel utilization efficiency (AFUE) of not less than 78 percent.

**405.5.3.2 Gas-fired furnaces.** Gas-fired furnaces shall have an AFUE of not less than 78 percent.

**405.5.4 Boilers.** Gas-fired boilers shall have an AFUE not less than 80 percent, and gas-fired steam boilers shall have an AFUE of not less than 75 percent.

**405.5.5 Packaged terminal air conditioners.** Packaged terminal air conditioners shall meet performance requirements as specified in Table 405.5.5.

**405.5.6 Packaged terminal heat pumps.** Packaged terminal heat pumps shall meet performance requirements as specified in Table 405.5.5.

**405.6 Economizer cooling.** Each fan system with mechanical cooling shall have an air economizer system capable of modulating outside air and return dampers to provide up to 100 percent of the design supply air quantity as outdoor air.

#### Exceptions:

1. Cooling equipment rated at less than 54,000 Btu/h (15 827 W) total cooling capacity.
2. HVAC systems serving guest rooms or dwelling units.
3. One- and two-family dwellings.

**TABLE 405.5.5  
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS (PTAC) AND PACKAGED  
TERMINAL HEAT PUMPS (PTHP) - MINIMUM EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATINGS CONDITIONS	MINIMUM EFFICIENCY REQUIRED	TEST PROCEDURE
PTAC, cooling mode New construction	All Capacities	95°F db Outdoor Air	12.5-(0.213x Cap/1000) EER <sup>a</sup>	ARI 310/380-93
PTAC, cooling mode Replacements <sup>b</sup>	All Capacities	95°F db Outdoor Air	10.9-(0.213x Cap/1000) EER <sup>a</sup>	
PTHP, (Cooling Mode) New construction	All Capacities	95°F db Outdoor Air	12.3-(0.213x Cap/1000) EER <sup>a</sup>	ARI 310/380-93
PTHP, (Cooling Mode) Replacements <sup>b</sup>	All Capacities	95°F db Outdoor Air	10.8-(0.213x Cap/1000) EER <sup>a</sup>	
PTHP, cooling mode New construction	All Capacities	—	3.2-(0.026 x Cap/1000) EER <sup>a</sup>	—
PTHP, (Heating Mode) Replacements <sup>b</sup>	All Capacities	—	2.9-(0.026 x Cap/1000) EER <sup>a</sup>	

For SI: 1 inch = 25.4 mm, 1 Btu/h = 0.2931W.

- a. Cap means the rated cooling capacity of the product in Btu/h. If the unit capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
- b. Replacement efficiencies shall only apply to units with existing sleeves less than 16 inches high and less than 42 inches wide. Replacement units shall be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS."

**SECTION 406  
PIPING INSULATION**

**406.1 Heating and cooling systems.** All piping serving as part of a heating or cooling system shall be thermally insulated as shown in Table 406.1.

**406.2 Domestic and service hot water systems.** All piping serving as part of a domestic or service hot water system shall be thermally insulated as shown in Table 406.1.

**Exception:** One- and two-family dwellings.

**406.3 Minimum thickness.** Insulation thicknesses shall be no less than specified in Table 406.1. However, a greater thickness insulation may be required for freeze protection where piping is exposed to subfreezing ambient temperatures.

**406.4 Water vapor transmission.** The minimum insulation thicknesses specified do not consider water vapor transmission and condensation. Additional insulation, vapor retarders, or both, may be required to limit water vapor transmission and condensation.

**Exception:** Piping insulation, except when needed to prevent condensation, is not required in any of the following cases:

1. Factory-installed piping within HVAC equipment.

2. Piping that conveys fluids that have a design operating temperature range between 55°F and 105°F (13°C and 40.5°C).

3. Piping installed in basements, cellars or unventilated crawl spaces with insulated walls.

**SECTION 407  
LIGHTING**

**407.1 General.** The provisions of this section apply to lighting equipment, related controls and electric circuits serving all conditioned and unconditioned interior floor space and exterior building facades of all dwelling units and guest rooms within residential buildings and structures, or portions thereof.

**407.2 High-efficiency lighting systems.** A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be compact or linear fluorescent, or a lighting source that has a minimum efficacy of 40 lumens per input watt.

The building official shall be notified in writing at the final inspection that a minimum of 50 percent of the lamps in permanently installed lighting fixtures are compact or linear fluorescent, or a minimum efficacy of 40 lumens per input watt.

**TABLE 406.1  
MINIMUM PIPE INSULATION (INCHES)<sup>a, b</sup>**

FLUID DESIGN OPERATING TEMPERATURE RANGE, °F	INSULATION CONDUCTIVITY		NOMINAL PIPE DIAMETER (IN.)				
	Conductivity range (Btu-in)/(hr.-ft <sup>2</sup> -°F)	Mean rating temperature °F	1 and less	1 1/4 to 2	2 1/2 to 4	5 & 6	8 & up
<b>Heating systems (steam, steam condensate and hot water)<sup>c</sup></b>							
Above 350	0.32 - 0.34	250	2.5	3.0	3.0	4.0	4.0
251 - 350	0.29 - 0.31	200	2.0	2.5	3.0	3.5	3.5
201 - 250	0.27 - 0.30	150	1.5	1.5	2.0	2	3.5
141 - 200	0.25 - 0.29	125	1.5	1.5	1.5	1.5	1.5
105 - 140	0.24 - 0.28	100	1.0	1.0	1.0	1.5	1.5
<b>Domestic and Service Hot Water System<sup>d</sup></b>							
105 and greater	0.24 - 0.28	100	1 <sup>e</sup>	1	1.5	1.5	1.5
<b>Cooling systems (chilled water, brine and refrigerant)<sup>c</sup></b>							
40-55	0.23 - 0.27	75	0.5	0.75	1.0	1.0	1.0
Below 40	0.23 - 0.27	75	1.0	1.5	1.5	1.5	1.5

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, °F = 1.8°C + 32

a. For insulation outside the stated conductivity range, minimum thickness (*T*) shall be determined as follows:

$$T = r\{(1 + t/r)K/k - 1\}$$

Where

*T* = minimum thickness (in.)

*r* = actual outside radius of pipe (in.)

*t* = insulation thickness in this table for applicable fluid temperature and pipe size.

*K* = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu-in.[h · ft<sup>2</sup> · °F]) and

*k* = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b. These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability, surface condensation, or safety considerations sometimes require vapor retarders or additional insulation.

c. Piping insulation is not required between the control valve and coil on run-outs when control valve is located within 4 feet of the coil and pipe diameter is 1 inch or less.

d. Applies to recirculating sections of service or domestic hot water systems and first 8 feet (2.4 mm) from storage tank for noncirculating systems.

e. Piping less than 1 inch in diameter and less than 12 feet in length shall be insulated with 1/2 inch insulation with a minimum conductivity of 0.24 Btu-in/hr · ft<sup>2</sup> · °F.

## PART II—ALTERNATIVE SYSTEMS ANALYSIS

### SECTION 408 ALTERNATIVE SYSTEMS ANALYSIS

*This section provides an alternate method of demonstrating code compliance with this chapter by demonstrating that such deviation will result in an annual energy consumption equal to or less than a building that is in compliance with this chapter.*

**408.1 Equivalent annual energy consumption.** The baseline design, conforming to requirements specified in this chapter and the proposed design shall be analyzed using the same procedures. The analyses shall use equal floor area and equal environmental requirements. The comparison shall be expressed in Btu input per gross building square foot of conditioned space per year (MJ/m<sup>2</sup> per year).

**408.2 Basis for comparison.** Both baseline and proposed alternative designs shall include parameters as specified in Table 408.2.

**408.2.1 Internal heat gain.** The total internal heat gain shall be calculated by Equation 408.2.1(1). For single zone calculations, the daily total sensible internal gains (Btu/day) shall be determined by Equation 408.2.1(2). For multiple zone HVAC systems, the daily total sensible internal gains (Btu/day) shall be determined by Equation 408.2.1(2) for the living zone and Equation 408.2.1(3) for the sleeping zone. The daily total latent load for each zone shall be determined using Equation 408.2.1(4).

Internal heat gains shall be distributed over the day according to the profile in Table 408.2.1(2). The load for each hour is the daily total gain multiplied by the factor from the appropriate column.

Where multiple zone space conditioning is modeled, the profile shown for Zone 2 shall be used for bedrooms and bathrooms; the profile shown for Zone 1 shall be used for all other conditioned rooms. Where single zone space conditioning is modeled, the hourly profile for single-zone designs shall be used.

**Equation 408.2.1(1)**

Total Heat Gains = Sensible Heat Gains + Latent Heat Gains

**Equation 408.2.1(2)**

Single Zone or Living Zone:

Sensible Heat Gains = (Floor Area of Zone × 15 Btu/day · ft<sup>2</sup>) + (Number of living units × 20,000 Btu/day)

**Equation 408.2.1(3)**

Sleeping Zone:

Sensible Heat Gains = Floor Area of Zone × 15 Btu/day · ft<sup>2</sup>

**Equation 408.2.1(4)**

Latent Heat Gains = 0.2 × Sensible Heat Gains

**TABLE 408.2  
BASIS FOR COMPARISON**

INPUT PARAMETERS FOR ANALYSIS		
Parameter	Proposed Building	Code Baseline
<b>Building Envelope</b>		
Opaque construction materials	As designed	Code minimum
Fenestration performance	As designed	Code minimum
Shading devices	As designed	Same as proposed
Window area	As designed	Same as proposed <sup>a</sup>
Skylight area	As designed	Same as proposed <sup>b</sup>
Building orientation	As designed	Same as proposed
Solar gain	As designed	Same as proposed
Building infiltration	0.35 ACH Natural	Same as proposed
<b>HVAC Systems</b>		
HVAC system type(s)	As designed	Same as proposed
HVAC efficiency	Code efficiencies <sup>c</sup>	Same as proposed <sup>c</sup>
Heating fuel	As designed	Same as proposed
Cooling fuel	As designed	Same as proposed
Temperature setpoints	As designed	Same as proposed
Equipment capacity	As designed	Same as proposed
Mechanical ventilation	As designed	Same as proposed
<b>Lighting</b>		
Artificial lighting	As designed	Code required
Daylighting	As designed	Same as proposed
<b>Design Conditions</b>		
Building occupancy	As designed	Same as proposed
Building operational schedules	As designed	Same as proposed
Climatic data	As designed	Same as proposed
Internal loads	As designed	Same as proposed
Cooking fuel	As designed	Same as proposed

- For a single family dwelling unit, detached or attached (rowhouse), only, code baseline window area may be set at 13 percent of heated space floor area when proposed building has less than 13 percent of heated space floor area in windows.
- Code baseline skylight area shall be same as proposed up to a maximum of 2 percent of the heated space floor area.
- Systems not regulated by code, such as electric heat, shall comply with standard equipment efficiency for such equipment.

**408.2.2 Thermostat set-points.** In the analysis for both the baseline and proposed designs, all conditioned spaces shall be maintained at the specified thermostat set-points at all times except for minor deviations at thermostat setback and setup and when outdoor conditions exceed normal design conditions.

If the specified equipment in the proposed design is too small to meet the load, its capacity shall be increased in the

calculations. If equipment to meet a load is not included in the design, such equipment shall be assumed in the calculations and its energy use included. In no case shall the energy use of proposed design be reduced by not conditioning its spaces.

For central space conditioning systems without zonal control, the entire conditioned floor area shall be one thermostatically controlled zone. The thermostat settings shall be those listed for a single zone in Table 408.2.2. For multiple zone designs, the multi-zone thermostat settings in Table 408.2.2 shall be used. Zone 1 represents all conditioned spaces other than Zone 2 (bedrooms and bathrooms). The effect of heat transfer between zones including nonclosable openings shall be included in the calculation.

**TABLE 408.2.2  
THERMOSTAT SETTINGS (°F)**

TIME OF DAY	SINGLE ZONE		MULTIPLE ZONE			
	Heat	Cool	Zone 1 Living		Zone 2 Sleeping	
			Heat	Cool	Heat	Cool
6-9 A.M.	68	78	68	78	68	78
9 A.M. – 5 P.M.	68	78	68	78	60	85
5-11 P.M.	68	78	68	78	68	78
11 P.M. – 6 A.M.	68	78	60	85	60	78

**408.3 Analysis procedure.** The analysis of the annual energy usage of the standard and the proposed alternative building and system designs shall meet the following criteria:

**408.3.1** The building heating/cooling load calculation procedure used for annual energy consumption analysis shall be of sufficient detail to permit the evaluation of effect of building data (such as orientation, size, shape, transfer characteristics of mass, air, moisture, and heat) and hourly climatic data.

**408.3.2** The calculation procedure used to simulate the operation of the building and its service systems through a full year operating period shall be of sufficient detail to permit the evaluation of the effect of system design, climatic factors operational characteristics, and mechanical equipment on annual energy usage. Manufacturer’s data or comparable field test data shall be used when available in the simulation of all systems and equipment. The calculation procedure shall be based upon 8760 hr of operation of the building and its service systems and shall utilize techniques recommended in the appropriate ASHRAE publications or produce results consistent with such recommended procedures.

**408.3.2.1** The calculation procedure shall explicitly cover the following items:

1. Climatic data: coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation.
2. Building data: orientation, size, shape, mass, air, moisture and heat transfer characteristics.

3. Operational characteristics: temperature, humidity, ventilation, illumination, control mode for occupied and nonoccupied hours.
4. Mechanical equipment: design capacity, part load profile.
5. Internal heat generation, lighting, equipment, number of people during occupied and non-occupied periods.

**408.4 Documentation.** Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis comparison report prepared by a registered engineer. The report shall provide sufficient technical detail describing the differences between the two building and systems designs and on the data used in and resulting from the comparative analysis.

**408.4.1** The documentation shall demonstrate that the analysis used is consistent with the techniques and procedures specified in this section and the following ASHRAE documents:

1. 2001 ASHRAE *Handbook of Fundamentals*.
2. 2000 ASHRAE *Handbook of HVAC Systems and Equipment*.
3. ASHRAE *Principles of Heating, Ventilating and Air Conditioning*.

**PART III—FENESTRATION STANDARD**

**SECTION 409  
SCOPE**

**409.1 General.** All windows installed in Oregon shall meet the requirements of this section.

**SECTION 410  
DEFINITIONS**

**410.1 General.** For purposes of this section the following definitions are provided;

1. “Windows produced in low volume” are a manufacturer’s product installed in Oregon during a calendar year that does not exceed: 750 windows, 500 glazed doors, 1,000 skylights and 25 complete solariums.
2. A “manufacturer” produces windows, assembles window components or does both. A “manufacturer” includes its subsidiaries, divisions and all other companies under common control or ownership.

**SECTION 411  
INSULATED GLASS CERTIFICATION**

**411.1 General.** Sealed insulated glass units shall conform to, or be in test for, ASTM E 774-97 Standard Specification for the Classification of the Durability of Sealed Insulating Glass Units Class CBA or ASTM E2190-02 Standard Specification for Insulating Glass Unit Performance and Evaluation under

the IGMA (Insulating Glass Manufacturers Alliance) approved certification program or equal and be installed in accordance to the latest IGMA Glazing Guidelines.

### SECTION 412 WINDOW THERMAL PERFORMANCE DESIGNATION FOR NEW BUILDINGS AND ADDITIONS

*The requirements of this section are not intended to waive or supersede any window thermal performance requirements under state or federal laws.*

**412.1 Manufactured windows.** *U*-factors for manufactured fenestration products (windows, skylights and doors) shall be determined in accordance with the National Fenestration Rating Council (NFRC) 100 2004 Procedure for Determining Fenestration Product *U*-Factors. The *U*-factors shall be labeled and certified in accordance with the NFRC Product Certification.

**412.2 Windows products exempt from testing.** Thermal performance testing is not required for:

1. Solariums and sunrooms with a minimum of 1/2-inch (12.7 mm) space between the panes.
2. Skylights constituting no more than 10 percent of total glazing in a dwelling.
3. Windows, glazed doors, skylights and solariums produced in low volume.
4. Skylights constructed with wood, thermal break aluminum or aluminum with vinyl frames with a glazing configuration of either: A minimum 1/2-inch (12.7 mm) space between the panes and low-*e* glass; or triple layered acrylic.
5. Decorative or unique architectural glazing not exceeding one percent of the heated space floor area.

**412.3 Thermal performance of exempted products.** The thermal performance of window products exempted from testing shall be determined by the following procedures:

1. Windows produced in low volume are assigned default *U*-factors prescribed in Section 412.4, Item 1.
2. Glazed doors produced in low volume are assigned default *U*-factors prescribed in Section 412.4, Item 2.
3. The procedures specified in ASHRAE *Handbook of Fundamentals*, Chapter 30, Table 4 using the vertical installation categories or its certified *U*-factor according to the NFRC procedure as specified in Section 412.1 for the vertical and overhead glazing contained in solariums.
4. The procedures specified in ASHRAE *Handbook of Fundamentals*, Chapter 30, Table 4 using sloped installation or its certified *U*-factor according to the NFRC procedure as specified in Section 412.2, Item 2.
5. Skylights specified in Section 412.2, Item 3 shall be assigned a default *U*-factor of 0.50.

**412.4 Thermal performance validation for windows produced in low volume or site-built.** Windows, glazed doors, skylights and solariums produced in low volume and meeting the requirements of this subsection may validate default *U*-factors by using:

1. Table 412.4(1) for windows, or
2. Table 412.4(2) for glazed doors, or
3. Table 412.4(1) for overhead glazing such as those installed in solariums, or
4. By assuming a *U*-0.50 default for skylights, not exempted by Section 412.2, Item 3 when constructed with thermal-break aluminum, or wood, or vinyl frames; with glazing constructed of either a minimum:
  - 4.1. 0.5 inch (12.7 mm) airspace between the glazing with low-*e* and argon gas-filled; or
  - 4.2. Two 0.5 inch (12.7 mm) airspace triple glazing, measured at the center of glazing.

### SECTION 413 THERMAL PERFORMANCE LABELING

The requirements of this section are not intended to waive or supersede any window label or disclosure requirements under state or federal laws.

**413.1 Labeling.** Labeling is not required for decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area and is exempt from Table 404.1(1) thermal performance calculations.

**413.2.** Except as provided in Section 413.1, all windows shall have labeling that is:

1. Imprinted, not handwritten;
2. Facing the interior of the room; and
3. Attached to the window until the building inspector inspects and verifies the labeling; and

**413.3.** Manufactured window labels shall also list the *U*-factor or *U*-factor Class.

**413.4 Skylights exempt from thermal performance standards.** Labels for skylights exempted from thermal performance standards under Section 412.2, Item 4, due to its frame and glazing configuration shall:

1. Contain the statement, "This skylight is not required to be tested or evaluated for thermal performance";
2. State "EXEMPT" in 0.75 inch (19.1 mm) high letters;
3. Specify "Issued (*Date of issue*)";
4. Specify the skylight components; and
5. Contain the statement, "Under ORS 455.525(4) this skylight is deemed to comply with Oregon's thermal performance standards regardless of *U*-factor."

TABLE 412.4 (1)  
APPROVED WINDOW DEFAULT U-VALUES<sup>a, b</sup>

DESCRIPTION <sup>c, d, e, f, g</sup> (inches)	FRAME TYPE <sup>h</sup>		
	ALUM. THERMAL BREAK <sup>i</sup>	WOOD/VINYL	ALUM CLAD WOOD/ REINFORCED VINYL <sup>j</sup>
Double, Clear 1/4	N/A	0.56	0.59
Double, Clear 1/4 + argon	0.63	0.53	0.56
Double, Low-e 4 1/4	0.61	0.52	0.54
Double, Low-e 2 1/4	0.58	0.49	0.51
Double, Low-e 1 1/4	0.55	0.47	0.49
Double, Low-e 4 1/4 + argon	0.55	0.47	0.49
Double, Low-e 2 1/4 + argon	0.52	0.43	0.46
Double, Low-e 1 1/4 + argon	0.50	0.41	0.43
Double, Clear 3/8	0.63	0.54	0.57
Double, Clear 3/8 + argon	0.60	0.51	0.54
Double, Low-e 4 3/8	0.57	0.48	0.51
Double, Low-e 2 3/8	0.54	0.45	0.48
Double, Low-e 1 3/8	0.51	0.43	0.46
Double, Low-e 4 3/8 + argon	0.53	0.44	0.47
Double, Low-e 2 3/8 + argon	0.49	0.41	0.44
Double, Low-e 1 3/8 + argon	0.47	0.39	0.41
Double, Clear 1/2	0.60	0.50	0.54
Double, Clear 1/2 + argon	0.58	0.48	0.51
Double, Low-e 4 1/2	0.53	0.44	0.47
Double, Low-e 2 1/2	0.50	0.41	0.44
Double, Low-e 1 1/2	0.47	0.39	0.42
Double, Low-e 4 1/2 + argon	0.50	0.42	0.44
Double, Low-e 2 1/2 + argon	0.46	0.37	0.40
Double, Low-e 1 1/2 + argon	0.43	0.35	0.38
Triple, Clear 1/4	0.52	0.42	0.44
Triple, Clear 1/4 + argon	0.49	0.39	0.42
Triple, Low-e 4 1/4	0.50	0.40	0.40
Triple, Low-e 2 1/4	0.48	0.39	0.41
Triple, Low-e 1 1/4	0.47	0.38	0.40
Triple, Low-e 4 1/4 + argon	0.46	0.37	0.39
Triple, Low-e 2 1/4 + argon	0.43	0.34	0.37
Triple, Low-e 1 1/4 + argon	0.42	0.34	0.36
Triple, Clear 1/2	0.46	0.37	0.40
Triple, Clear 1/2 + argon	0.45	0.36	0.38
Triple, Low-e 4 1/2	0.43	0.35	0.37
Triple, Low-e 2 1/2	0.41	0.32	0.35
Triple, Low-e 1 1/2	0.39	0.31	0.33
Triple, Low-e 4 1/2 + argon	0.41	0.32	0.35
Triple, Low-e 2 1/2 + argon	0.38	0.30	0.32
Triple, Low-e 1 1/2 + argon	0.37	0.29	0.31

For SI: 1 inch = 25.4 mm.

- a. Subtract 0.02 from the listed default U-factor for insulated spacers. Insulated spacer material includes fiberglass, wood and butyl or other material with an equivalent K-value.
- b. Solariums may subtract 0.03 from the default U-factor.
- c. 1/4" = a minimum dead air space of 0.25 inch between the panes of glass.  
 3/8" = a minimum dead air space of 0.375 inch between the panes of glass.  
 1/2" = a minimum dead air space of 0.5 inch between the panes of glass.  
 Products with air spaces different than those listed above shall use the value for the next smaller air space; i.e. 3/4" = 1/2" U-factors, 7/16" = 3/8" U-factors, 5/16" = 1/4" U-factors.
- d. Low-e4 (emissivity) shall be 0.4 or less.  
 Low-e2 (emissivity) shall be 0.2 or less.  
 Low-e1 (emissivity) shall be 0.1 or less.

(continued)

**TABLE 412.4 (1)—continued**  
**APPROVED WINDOW DEFAULT U-VALUES<sup>a, b</sup>**

- e. *U*-factors listed for argon shall consist of sealed, gas-filled, insulated units for argon, CO<sub>2</sub>, SF<sub>6</sub> and argon/SF<sub>6</sub> mixtures.  
The following conversion factor shall apply to Krypton gas-filled units:  $\frac{1}{4}$ " or greater airspace with Krypton gas fill =  $\frac{1}{2}$ " airspace with Argon gas-fill.
- f. Dividers placed between glazing: The *U*-factors listed shall be used where the divider has a minimum gap of  $\frac{1}{8}$ -inch between the divider and lite of each inside glass surface. Add 0.03 to the listed *U*-factor for true divided lite windows.
- g. "Glass block" assemblies may use a *U*-factor of 0.51.
- h. Insulated fiberglass framed products shall use wood/vinyl *U*-factors.
- i. Alum. Thermal Break = An aluminum thermal break framed window shall incorporate the following minimum design characteristics:
  - 1) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/hr/ft<sup>2</sup>/°F;
  - 2) The thermal break material shall not be less than 0.210 inch; and
  - 3) All metal framing members of the product to interior and exterior air must incorporate a thermal break meeting the criteria in 1) and 2) above.
- j. Aluminum clad wood windows shall use the *U*-factors listed for aluminum clad wood/reinforced vinyl windows. Vinyl clad windows shall use the *U*-factors listed for wood/vinyl windows. Any vinyl frame window with metal reinforcement in more than one rail shall use the *U*-factors listed for aluminum clad wood reinforced vinyl windows.

**TABLE 412.4 (2)  
APPROVED GLAZED DOOR DEFAULT U-VALUES<sup>a</sup>**

DESCRIPTION <sup>b, c, d, e</sup> (inches)	DOOR MATERIAL			
	INSULATED <sup>f</sup>		WOOD <sup>g</sup>	
	Full-Lite <sup>h, i</sup>	Half-Lite <sup>j, k</sup>	Full-Lite <sup>h</sup>	Half-Lite <sup>j</sup>
Double, Clear ¼	0.39	0.31	0.47	0.42
Double, Clear ¼ + argon	0.37	0.30	0.45	0.41
Double, Low-e 4¼	0.36	0.30	0.44	0.41
Double, Low-e 2¼	0.35	0.29	0.43	0.40
Double, Low-e 1¼	0.24	0.28	0.41	0.39
Double, Low-e 4¼ + argon	0.33	0.28	0.41	0.39
Double, Low-e 2¼ + argon	0.31	0.26	0.39	0.38
Double, Low-e 1¼ + argon	0.31	0.26	0.38	0.37
Double, Clear ¾	0.37	0.30	0.45	0.41
Double, Clear ¾ + argon	0.36	0.29	0.44	0.41
Double, Low-e 4¾	0.34	0.28	0.42	0.40
Double, Low-e 2¾	0.33	0.28	0.41	0.39
Double, Low-e 1¾	0.21	0.26	0.38	0.37
Double, Low-e 4¾ + argon	0.32	0.27	0.40	0.38
Double, Low-e 2¾ + argon	0.29	0.25	0.37	0.37
Double, Low-e 1¾ + argon	0.29	0.25	0.36	0.36
Double, Clear ½	0.36	0.29	0.44	0.41
Double, Clear ½ + argon	0.34	0.28	0.42	0.40
Double, Low-e 4½	0.32	0.27	0.40	0.38
Double, Low-e 2½	0.30	0.26	0.38	0.37
Double, Low-e 1½	0.19	0.25	0.36	0.36
Double, Low-e 4½ + argon	0.30	0.26	0.38	0.37
Double, Low-e 2½ + argon	0.28	0.25	0.36	0.36
Double, Low-e 1½ + argon	0.28	0.24	0.34	0.35
Triple, Clear ¼	0.31	0.26	0.39	0.38
Triple, Clear ¼ + argon	0.29	0.25	0.37	0.37
Triple, Low-e 4¼	0.30	0.26	0.38	0.37
Triple, Low-e 2¼	0.29	0.25	0.37	0.36
Triple, Low-e 4¼ + argon	0.27	0.24	0.35	0.35
Triple, Low-e 2¼ + argon	0.26	0.24	0.34	0.35

For SI: 1 inch = 25.4 mm.

- a. Subtract 0.02 from the listed default *U*-factor for insulated spacers. Insulated spacer material includes fiberglass, wood and butyl or other material with an equivalent *K*-value.
- b. ¼" = a minimum dead air space of 0.25 inch between the panes of glass.  
¾" = a minimum dead air space of 0.375 inch between the panes of glass.  
½" = a minimum dead air space of 0.5 inch between the panes of glass.  
Products with air spaces different than those listed above shall use the value for the next smaller air space; i.e. ¾-inch = ½-inch *U*-factors, 7/16-inch = ¾-inch *U*-factors, 5/16" = ¼" *U*-factors.
- c. Low-*e4* (emissivity) shall be 0.4 or less.  
Low-*e2* (emissivity) shall be 0.2 or less.  
Low-*e1* (emissivity) shall be 0.1 or less.
- d. *U*-factors listed for argon shall consist of sealed, gas-filled, insulated units for argon, CO<sub>2</sub>, SF<sub>6</sub> and argon/SF<sub>6</sub> mixtures.  
The following conversion factor shall apply to Krypton gas-filled units:  
¼-inch or greater airspace with Krypton gas fill = ½-inch airspace with Argon gas-fill.
- e. Dividers placed between glazing: The *U*-factors listed shall be used where the divider has a minimum gap of 1/8-inch between the divider and lite of each inside glass surface. Add 0.03 to the listed *U*-factor for True Divided Lite windows.
- f. Insulated = Any urethane insulated foam core door with a thermal break. Thermal Break = A thermal break door shall incorporate the following minimum design characteristics:
  - 1) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/hr/ft<sup>2</sup>°F; and
  - 2) The thermal break material shall not be less than 0.210 inch.
- g. Wood = Any wood door.
- h. Full Lite = A door that consists of more than 35 percent glazing.
- i. Add 0.05 to the listed *U*-factor for full-lite values if insulated door does not have a thermal break.
- j. Half Lite = A door that consists of 35 percent or less glazing.
- k. Add 0.06 to the listed *U*-factor for half-lite values if the insulated door does not have a thermal break.

**413.5 Solariums and skylights exempt from testing.**

Labels for solariums and sunrooms with 0.5 inch (12.7 mm) airspace between the glazing and skylights less than 10 percent of the total glazing in a dwelling exempt from thermal performance testing under Section 412.2, Items 1, 2 and 4 shall:

1. Specify the window components and configuration; and
2. Show the *U*-value determined by Section 412.3, Item 3.

**Exception:** Exempt solariums and skylights may be labeled as certified through the NFRC procedure as specified in Section 412.1.

**413.6 Windows produced in low volume or site-built.** Labeling and disclosure shall comply with the following subsections:

**413.6.1** Labels for windows and glazed doors produced in low volume shall:

1. Specify window components;
2. Show the allowed *U*-factor in the appropriate location;
3. Show a production count number that does not exceed the maximums established in Section 410, Item 1; and
4. Imprint “(Manufacturer’s name) certifies the attached window is constructed in a manner to obtain the specified *U*-factor.”

**413.6.2** Labels for skylights produced in low volume, when constructed with thermal-break aluminum, or wood, or vinyl frames; with glazing constructed of either a minimum 0.5 inch (12.7 mm) airspace between the glazing with low-e and argon gas-filled; or of two 0.5 inch (12.7 mm) airspace triple glazing, measured at the center of glazing; for the *U*-0.50 requirement shall:

1. Specify window components;
2. State “*U*-0.50 Default *U*-factor”;
3. State “Limited Production Skylight Compliance *U*-factor Label” and “Maximum Allowable Skylight Area Shall Not Exceed Two Percent of the Heated Space Floor Area”;
4. Show a production count number that does not exceed the maximums established in Section 410.1, Item 1; and
5. Imprint “(Manufacturer’s name) certifies the attached skylight complies with the criteria specified in the Oregon building codes.”

**413.6.3** Labels for skylights produced in low volume, not meeting the construction and configuration requirements of Section 413.6.2 and not otherwise exempt under Section 412.2, Item 4 shall:

1. Specify window components;
2. State “Calculated *U*-factor Skylight Compliance Label”;
3. Show the *U*-factor determined by Section 412.3, Item 4; and
4. Show a production count number that does not exceed the maximums established in Section 410.1, Item 1.

**413.6.4** Labels for solariums produced in low volume shall:

1. Specify the window components for each of the glazed surfaces, such as the front, overhead, and each side;
2. Show a production count number that does not exceed the maximums established in Section 410, Item 1;
3. Show the *U*-factor determined by Sections 412.4 Items 1 and 3 for each of the glazed surfaces;
4. Imprint “(Manufacturer’s name) certifies the components of this solarium are constructed in a manner to obtain the specified *U*-factors”; and
5. Have one label providing a description of each of the glazed surfaces.

**Exception:** Products specified in Sections 413.6.1, 413.6.2 and 413.6.3, may be labeled as certified through the NFRC procedure as specified in Section 412.1.

**413.7 Combined products.** When different window types are combined, mullled together by the manufacturer or manufactured to fit a framed rough opening, a single label may be used.

**Exception:** A solarium shall have one label providing a description of each of the glazed surfaces, such as the front, overhead, and each side.

**413.8 Label distribution.** Labels under Sections 412.2 through 412.4 shall be designed by the division and sold by persons authorized by the agency and shall not be sold in lots exceeding the maximums for each window type per manufacturer during any calendar year.

## SECTION 414 AIR LEAKAGE REQUIREMENTS

Windows shall comply with the air leakage requirements of Section 404.8.

**Exception:** Site-built windows.

## SECTION 415 ALTERATIONS

New windows shall have maximum *U*-factor of 0.40. Windows shall be tested and labeled in accordance with Sections 404.4.

**Exceptions:**

1. Skylights allowed under Section 412.2, Item 4.
2. Decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area may be exempt from thermal performance testing and labeling, and Table 404.1(1) calculations.
3. Where necessary to retain architectural consistency with remaining windows in the building, new windows shall have a maximum *U*-factor of 0.65.

