2009 IECC Based
2010 Florida Building Code

CHAPTER 5
COMMERCIAL ENERGY EFFICIENCY

SECTION 501 GENERAL

501.1 Scope. The requirements contained in this chapter are applicable to commercial buildings, or portions of commercial buildings. ~~These commercial buildings shall meet either the requirements of ASHRAE/IESNA Standard 90.1, *Energy Standard for Buildings Except for Low-Rise Residential Buildings*, or the requirements contained in this chapter.~~

501.2 Application. The *commercial building* project shall comply with the requirements in Sections 502 (Building envelope requirements), 503 (Building mechanical systems), 504 (Service water heating) and 505 (Electrical power and lighting systems) in its entirety. As an alternative the *commercial building* project shall comply with the requirements of ~~ASHRAE/IESNA 90.1 in its entirety.~~

~~Exception:~~ ~~Buildings conforming to~~ Section 506, provided Sections 502.4, 503.2, 504, 505.2, 505.3, 505.4, 505.6 and 505.7 are each satisfied.

SECTION 502
BUILDING ENVELOPE REQUIREMENTS

502.1 General (Prescriptive).

502.1.1 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Tables 502.2(1) and 502.3 based on the climate *zone* specified in Chapter 3. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *R*-values from the "Group R" column of Table 502.2(1). Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *R*-values from the "All other" column of Table 502.2(1). Buildings with a vertical fenestration area or skylight area that exceeds that allowed in Table 502.3 shall comply with the building envelope provisions of ASHRAE/IESNA90.1.

502.1.2 *U*-factor alternative. An assembly with a *U*-factor, *C*-factor, or *F*-factor equal or less than that specified in Table 502.1.2 shall be permitted as an alternative to the *R*-value in Table 502.2(1). Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *U*-factor, *C*-factor, or *F*-factor from the "Group R" column of Table 502.1.2. Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *U*-factor, *C*-factor or *F*-factor from the "All other" column of Table 502.1.2.

502.2 Specific insulation requirements (Prescriptive). Opaque assemblies shall comply with Table 502.2(1).

502.2.1 Roof assembly. The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table 502.2(1), based on construction materials used in the roof assembly.

Exception: Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted *U*-factor is equivalent to the same assembly with the *R*-value specified in Table 502.2(1).

502.2.1.1 Vented Cavities above Dropped Ceilings. Where cavities beneath a roof deck are not sealed from the outside environment, the ceiling shall be treated as the exterior thermal and pressure envelopes of the building.

502.2.1.2 Cavities Used as Plenums. Cavities beneath a roof deck which will be used as return plenums shall have a roof insulated to at least R-19.

502.2.1.3 Ceiling insulation. Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation unless the roof/ceiling cavity is sealed from the exterior environment.

502.2.2 Classification of walls. Walls associated with the building envelope shall be classified in accordance with Section 502.2.2.1 or 502.2.2.2.

502.2.2.1 Above-grade walls. Above-grade walls are those walls covered by Section 502.2.3 on the exterior of the building and completely above grade or walls that are more than 15 percent above grade.

502.2.2.2 Below-grade walls. Below-grade walls covered by Section 502.2.4 are basement or first-story walls associated with the exterior of the building that are at least 85 percent below grade.

502.2.3 Above-grade walls. The minimum thermal resistance (*R*-value) of the insulating material(s) installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table 502.2(1), based on framing type and construction materials used in the wall assembly. The *R*-value of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table 502.2(1). "Mass walls" shall include walls weighing at least (1) 35 pounds per square foot (170 kg/m^2) of wall surface area or (2) 25 pounds per square foot (120 kg/m^2) of wall surface area if the material weight is not more than 120 pounds per cubic foot (1900 kg/m^3).

502.2.4 Below-grade walls. The minimum thermal resistance (*R*-value) of the insulating material installed in, or continuously on, the below-grade walls shall be as specified in Table 502.2(1), and shall extend to a depth of 10 feet (3048 mm) below the outside finished ground level, or to the level of the floor, whichever is less.

502.2.5 Floors over outdoor air or unconditioned space. The minimum thermal resistance (*R*-value) of the insulating material installed either between the floor framing or continuously on the floor assembly shall be as specified in Table 502.2(1), based on construction materials used in the floor assembly.

"Mass floors" shall include floors weighing at least (1) 35 pounds per square foot (170 kg/m^2) of floor surface area or (2) 25 pounds per square foot (120 kg/m^2) of floor surface area if the material weight is not more than 12 pounds per cubic foot (1,900 kg/m^3).

502.2.6 Slabs on grade. The minimum thermal resistance (*R*-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors shall be as specified in Table 502.2(1). The insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table.

502.2.7 Opaque doors. Opaque doors (doors having less than 50 percent glass area) shall meet the applicable requirements for doors as specified in Table 502.2(1) and be considered as part of the gross area of above-grade walls that are part of the building envelope.

TABLE 502.1.2
[Values to be proposed before Work Group meeting]
BUILDING ENVELOPE REQUIREMENTS OPAQUE ELEMENT, MAXIMUM U-FACTORS

CLIMATE ZONE	1		2	
	All other	Group R	All other	Group R
Roofs				
Insulation entirely above deck	~~U 0.063~~	~~U 0.048~~	~~U 0.048~~	~~U 0.048~~
Metal buildings	~~U 0.065~~	~~U 0.065~~	~~U 0.055~~	~~U 0.055~~
Attic and other	~~U 0.034~~	~~U 0.027~~	~~U 0.027~~	~~U 0.027~~
Walls, above grade				
Mass	~~U 0.058~~	~~U 0.151~~	~~U 0.151~~	~~U 0.123~~
Metal building	~~U 0.093~~	~~U 0.093~~	~~U 0.093~~	~~U 0.093~~
Metal framed	~~U 0.124~~	~~U 0.124~~	~~U 0.124~~	~~U 0.064~~
Wood framed and other	~~U 0.089~~	~~U 0.089~~	~~U 0.089~~	~~U 0.089~~
Walls, below grade				
Below-grade wall[1]	~~C 1.140~~	~~C 1.140~~	~~C 1.140~~	~~C 1.140~~
Floors				
Mass	~~U 0.322~~	~~U 0.322~~	~~U 0.107~~	~~U 0.187~~
Joist/Framing	~~U 0.282~~	~~U 0.282~~	~~U 0.052~~	~~U 0.052~~
Slab-on-grade Floors				
Unheated slabs	~~F 0.730~~	~~F 0.730~~	~~F 0.730~~	~~F 0.730~~
Heated slabs	~~F 1.020~~	~~F 1.020~~	~~F 1.020~~	~~F 1.020~~

[1] When heated slabs are placed below-grade, below grade walls must meet the F-factor requirements for perimeter insulation according to the heated slab-on-grade construction.

TABLE 502.2(1)
[Values to be proposed before Work Group meeting]
BUILDING ENVELOPE REQUIREMENTS--OPAQUE ASSEMBLIES

CLIMATE ZONE	1		2	
	All other	Group R	All other	Group R
Roofs				
Insulation entirely above deck	~~R-15ci~~	~~R-20ci~~	~~R-20ci~~	~~R-20ci~~
Metal buildings with R-5 thermal blocks[a,b]	~~R-19~~	~~R-19~~	~~R-13 + R-13~~	~~R-13 + R-13~~
Attic and other	~~R-30~~	~~R-38~~	~~R-38~~	~~R-38~~
Walls, above grade				
Mass	~~NR~~	~~R-5.7ci[c]~~	~~R-5.7ci[e]~~	~~R-7.6ci~~
Metal building[b]	~~R-16~~	~~R-16~~	~~R-16~~	~~R-16~~
Metal framed	~~R-13~~	~~R-13~~	~~R-13~~	~~R-13 + 7.5ci~~
Wood framed and other	~~R-13~~	~~R-13~~	~~R-13~~	~~R-13~~
Walls, below grade				
Below-grade wall[d]	NR	NR	NR	NR
Floors				
Mass	NR	NR	~~R-6.3ci~~	~~R-8.3ci~~
Joist/Framing (steel/wood)	NR	NR	~~R-19~~	~~R-30~~
Slab-on-grade Floors				
Unheated slabs	NR	NR	NR	NR
Heated slabs	~~R-7.5 for 12 in. below~~	~~R-7.5 for 12 in. below~~	~~R-7.5 for 12 in. below~~	~~R-7.5 for 12 in. below~~
Opaque Doors				
Swinging	~~U-0.70~~	~~U-0.70~~	~~U-0.70~~	~~U-0.70~~
Roll-up or sliding	~~U-1.45~~	~~U-1.45~~	~~U-1.45~~	~~U-1.45~~

[a] When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. [See Tables 502.1.2 and 502.2(2)].
[b] Assembly descriptions can be found in Table 502.2(2).
[c] R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu-=in./hr · ft^{2} · °F.
[d] When heated slabs are placed below grade, below-grade walls must meet the exterior insulation requirements for perimeter insulation according to the heated slab-on-grade construction.
[e] Steel floor joist systems shall be R-38.

TABLE 502.2(2)
BUILDING ENVELOPE REQUIREMENTS—OPAQUE ASSEMBLIES

	DESCRIPTION	REFERENCE
Roofs		
R-19	Standing seam roof with single fiberglass insulation layer. This construction is R-19 faced fiberglass insulation batts draped perpendicular over the purlins. A minimum R-3.5 thermal spacer block is placed above the purlin/batt, and the roof deck is secured to the purlins.	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"
R-13 + R-13 R-13 + R-19	Standing seam roof with two fiberglass insulation layers. The first R-value is for faced fiberglass insulation batts draped over purlins. The second R-value is for unfaced fiberglass insulation batts installed parallel to the purlins. A minimum R-3.5 thermal spacer block is placed above the purlin/batt, and the roof deck is secured to the purlins.	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"
R-11 + R-19 FC	Filled cavity fiberglass insulation.	ASHRAE/IESNA 90.1 Table A2.3 including

	A continuous vapor barrier is installed below the purlins and uninterrupted by framing members. Both layers of uncompressed, unfaced fiberglass insulation rest on top of the vapor barrier and are installed parallel, between the purlins. A minimum R-3.5 thermal spacer block is placed above the purlin/batt, and the roof deck is secured to the purlins.	Addendum "G"
Walls		
R-16, R-19	Single fiberglass insulation layer. The construction is faced fiberglass insulation batts installed vertically and compressed between the metal wall panels and the steel framing.	ASHRAE/IESNA 90.1 Table A3.2 including Addendum "G"
R-13 + R-5.6ci R-19 + R-5.6ci	The first R-value is for faced fiberglass insulation batts installed perpendicular and compressed between the metal wall panels and the steel framing. The second rated R-value is for continuous rigid insulation installed between the metal wall panel and steel framing, or on the interior of the steel framing.	ASHRAE/IESNA 90.1 Table A3.2 including Addendum "G"

502.3 Fenestration (Prescriptive). Fenestration shall comply with Table 502.3.

502.3.1 Maximum area. The vertical fenestration area (not including opaque doors) shall not exceed the percentage of the gross wall area specified in Table 502.3. The skylight area shall not exceed the percentage of the gross roof area specified in Table 502.3.

502.3.2Maximum*U*-factor and SHGC. For vertical fenestration, the maximum *U*-factor and solar heat gain coefficient (SHGC) shall be as specified in Table 502.3, based on the window projection factor. For skylights, the maximum *U*-factor and solar heat gain coefficient (SHGC) shall be as specified in Table 502.3. The window projection factor shall be determined in accordance with Equation 5-1.

$PF = A/B$ **(Equation 5-1)**

where:

PF = Projection factor (decimal).

A = Distance measured horizontally from the furthest continuous extremity of any overhang, eave, or permanently attached shading device to the vertical surface of the glazing.

B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or permanently attached shading device.

Where different windows or glass doors have different *PF* values, they shall each be evaluated separately, or an area-weighted *PF* value shall be calculated and used for all windows and glass doors.

TABLE 502.3
[Values to be proposed before Work Group meeting]
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

CLIMATE ZONE	1	2
Vertical fenestration (40% maximum of above-grade wall)		
U-factor		
Framing materials other than metal with or without metal reinforcement or cladding		
U-factor	~~1.20~~	~~0.75~~
Metal framing with or without thermal break		
Curtain wall/storefront U-factor	~~1.20~~	~~0.70~~
Entrance door U-factor	~~1.20~~	~~1.10~~
All other U-factor[a]	~~1.20~~	~~0.75~~
SHGC—all frame types		
SHGC: PF < 0.25	~~0.25~~	~~0.25~~

SHGC: 0.25 ≤PF < 0.5	~~0.33~~	~~0.33~~
SHGC: PF ≥ 0.5	~~0.40~~	~~0.40~~
Skylights (3% maximum)		
U-factor	~~0.75~~	~~0.75~~
SHGC	~~0.35~~	~~0.35~~

NR = No requirement
PF = Projection factor (See Section 502.3.2).
[a]. All others includes operable windows, fixed windows and non-entrance doors.

502.4 Air leakage (Mandatory).

502.4.1 Window and door assemblies. The air leakage of window and sliding or swinging door assemblies that are part of the building envelope shall be determined in accordance with AAMA/WDMA/CSA 101/I.S.2/A440, or NFRC 400 by an accredited, independent laboratory, and *labeled* and certified by the manufacturer and shall not exceed the values in Section 402.4.2.

Exception: Site-constructed windows and doors that are weatherstripped or sealed in accordance with Section 502.4.3.

502.4.2 Curtain wall, storefront glazing and commercial entrance doors. Curtain wall, *storefront* glazing and commercial-glazed swinging entrance doors and revolving doors shall be tested for air leakage at 1.57 pounds per square foot (psf) (75 Pa) in accordance with ASTM E 283. For curtain walls and *storefront* glazing, the maximum air leakage rate shall be 0.3 cubic foot per minute per square foot (cfm/ft$_2$) (5.5 m$_3$/h × m$_2$) of fenestration area. For commercial glazed swinging entrance doors and revolving doors, the maximum air leakage rate shall be 1.00 cfm/ft$_2$ (18.3 m$_3$/h × m$_2$) of door area when tested in accordance with ASTM E 283.

502.4.3 Sealing of the building envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

502.4.4 Apertures in The Building Envelope. Any intentional apertures or openings in walls, ceilings or floor between conditioned and unconditioned space (such as hydrostatic openings in stairwells for coastal buildings) shall have dampers which limit air flow between the spaces.

502.4.5 Building Cavities.

502.4.5.1 Where vented dropped ceiling cavities occur over conditioned spaces, the ceiling shall be considered to be both the upper thermal envelope and pressure envelope of the building and shall contain a continuous air barrier between the conditioned space and the vented unconditioned space that is also sealed to the air barrier of the walls. See the definition of air barrier in Section 202.

502.4.5.2 Where unvented dropped ceiling cavities occur over conditioned spaces that do not have an air barrier between the conditioned and unconditioned space (such as T-bar ceilings), they shall be completely sealed from the exterior environment (at the roof plane) and adjacent spaces by a continuous air barrier that is also sealed to the air barrier of the walls. In that case, the roof assembly shall constitute both the upper thermal envelope and pressure envelope of the building.

502.4.5.3 Unconditioned spaces above separate tenancies shall contain dividing partitions between the tenancies to form a continuous air barrier that is sealed at the ceiling and roof to prevent air flow between them.

502.4.5.4 Building cavities designed to be air distribution system components shall be sealed according to the criteria for air ducts, plenums, etc. in Section 503.2.7.

~~**502.4.4 Hot gas bypass limitation.** Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table 502.4.4.~~

~~**Exception:** Unitary packaged systems with cooling capacities not greater than 90,000 Btu/h (26 379 W).~~

~~**TABLE 502.4.4 MAXIMUM HOT GAS BYPASS CAPACITY.**~~ [Does not belong under air infiltration.]

~~**502.4.5 Outdoor air intakes and exhaust openings.** Stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage rated damper with a maximum leakage rate of 4 cfm per square foot (6.8 L/s · C m$_2$) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance with AMCA 500D.~~

~~**Exception:** Gravity (nonmotorized) dampers are permitted to be used in buildings less than three stories in height above grade.~~ [Move to 503.2.4.4 Does not belong under air infiltration.]

502.4.6 Loading dock weatherseals. Cargo doors and loading dock doors shall be equipped with weatherseals to restrict infiltration when vehicles are parked in the doorway.

502.4.7 Vestibules. Reserved. ~~A door that separates *conditioned space* from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time.~~

~~**Exceptions:**~~

~~1. Buildings in climate Zones 1 and 2 as indicated in Figure 301.1 and Table 301.1.~~

~~2. Doors not intended to be used as a building *entrance door*, such as doors to mechanical or electrical equipment rooms.~~

~~3. Doors opening directly from a *sleeping unit* or dwelling unit.~~

~~4. Doors that open directly from a space less than 3,000 square feet (298 m_2) in area.~~

~~5. Revolving doors.~~

~~6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.~~

502.4.8 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and *labeled* as meeting ASTM E 283 when tested at 1.57 psf (75 Pa) pressure differential with no more than 2.0 cfm (0.944 L/s) of air movement from the *conditioned space* to the ceiling cavity. All recessed luminaires shall be sealed with a gasket or caulk between the housing and interior wall or ceiling covering.

SECTION 503
BUILDING MECHANICAL SYSTEMS

503.1 General. Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Section 503.2 (referred to as the mandatory provisions) and either:

1. Section 503.3 (Simple systems), or
2. Section 503.4 (Complex systems.

503.2 Provisions applicable to all mechanical systems (Mandatory).

503.2.1 Calculation of heating and cooling loads. Design loads shall be determined in accordance with the procedures described in the ASHRAE/ ACCA Standard 183 and shall be attached to the code compliance form submitted to the building department when the building is permitted or, in the event the mechanical permit is obtained at a later time, the sizing calculation shall be submitted with the application for the mechanical permit. Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook*. Alternatively, design loads shall be determined by an *approved* equivalent computation procedure, using the design parameters specified in Chapter 3.

Exception:

Where mechanical systems are designed by an engineer registered in the State of Florida, the engineer has the option of submitting a signed and sealed summary sheet to the building department in lieu of the complete sizing calculation(s). Such summary sheet shall include the following (by zone):

Project name/owner	Outdoor dry bulb used	Indoor dry bulb
Project address	Outdoor wet bulb used	Total cooling required with outside air
Total sensible gain	Grains water (difference)	Total heating required with outside air
Sizing method used	Relative humidity	
Total latent gain	Area in sq.ft.	

503.2.2 Equipment and system sizing. Heating and cooling equipment and systems capacity shall not exceed the loads calculated in accordance with Section 503.2.1. A single piece of equipment providing both heating and cooling must satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

Exceptions:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.

2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.
3. When the equipment selected is the smallest size needed to meet the load within available options of the desired equipment line.

503.2.2.1 Buildings that contain assembly occupancies shall have equipment sized or controlled to prevent continuous space cooling or heating of such spaces with peak capacity equipment by the following options:

1. Equipment is staged to include cooling or heating to the space and stages are controlled by an electronically controlled energy management system.
2. A separate cooling or heating system is utilized to provide cooling or heating to the assembly occupancy.
3. A variable speed compressor is utilized to provide incremental cooling or heating to the assembly occupancy.

503.2.3 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables 503.2.3(1), 503.2.3(2), 503.2.3(3), 503.2.3(4), 503.2.3(5), 503.2.3(6) and 503.2.3(7) when tested and rated in accordance with the applicable test procedure. 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. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

Exception: Water-cooled centrifugal water-chilling packages listed in Table 503.2.3(7) not designed for operation at ARHI Standard 550/590 test conditions of 44°F (7°C) leaving chilled water temperature and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 I/s.kW) condenser water flow shall have maximum full load and NPLV ratings adjusted using the following equations:

Adjusted maximum full load kW/ton rating = [full load kW/ton from Table 503.2.3(7)]/K_{adj}

Adjusted maximum NPLV rating = [IPLV from Table 503.2.3(7)]/K_{adj}

where:

$K_{adj} = 6.174722 - 0.303668(X) + 0.00629466(X)_2 - 0.000045780(X)_3$

$X = DT_{std} + LIFT$

DT_{std} = {24+[full load kW/ton from Table 503.2.3(7)] × 6.83}/Flow

Flow = Condenser water flow (GPM)/Cooling Full Load Capacity (tons)

LIFT = CEWT – CLWT (_F)

CEWT = Full Load Condenser Entering Water Temperature (_F)

CLWT = Full Load Leaving Chilled Water Temperature (_F)

The adjusted full load and NPLV values are only applicable over the following full-load design ranges:

Minimum Leaving Chilled Water Temperature: 38°F (3.3°C)

Maximum Condenser Entering Water Temperature: 102°F (38.9°C)

Condensing Water Flow: 1 to 6 gpm/ton 0.018 to 0.1076 1/s _ kW) and X _ 39 and _ 60

Chillers designed to operate outside of these ranges or applications utilizing fluids or solutions with secondary coolants (e.g., glycol solutions or brines) with a freeze point of 27°F (-2.8°C) or lower for freeze protection are not covered by this code.

TABLE 503.2.3(1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Conditioners, Air Cooled	<65,000 Btu/h[d]	Split System	13.0 SEER	ARI 210/240
		Single Package	13.0 SEER	

	≥65,000 Btu/h and <135,000 Btu/h	Split System and Single Package	11.2 EER[c]	
	≥135,000 Btu/h and <240,000 Btu/h	Split System and Single Package	11.0 EER[c]	ARI 340/360
	≥240,000 Btu/h and <760,000 Btu/h	Split System and Single Package	10.0 EER[c], 9.7 IPLV[g]	
	≥760,000 Btu/h	Split System and Single Package	9.7 EER[c], 9.4 IPLV[c]	
Through-the Wall, Air-cooled	≤30,000 Btu/h[d]	Split System	12.0 SEER	ARI 210/240
		Single Package	12.0 SEER	
Small-Duct High-Velocity, Air cooled	<65,000 Btu/h[c]	Split system or Single Package	11.0 SEER	
Space constrained products, air conditioners	<65,000 Btu/h[c]	Split system or Single Package	12.0 SEER[e]	
Air Conditioners, Water and Evaporatively Cooled	<65,000 Btu/h	Split System and Single Package	12.1 EER	ARI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Split System and Single Package	11.5 EER[c]	
	≥135,000 Btu/h and <240,000 Btu/h	Split System and Single Package	11.0 EER[c]	ARI 340/360
	≥240,000 Btu/h	Split System and Single Package	11.5 EER[c]	
Condensing Units, Air Cooled	≥135,000 Btu/h		10.1 EER, 11.2 IPLV	ARI 365
Condensing Units, Water or Evaporatively Cooled	≥135,000 Btu/h		13.1 EER, 13.1 IPLV	

For SI: °C – [(°F) – 32]/1.8 British thermal unit per hour – 0.2931 W. db = dry-bulb temperature, °F wb = wet-bulb temperature, °F

[a] Chapter 6 contains a complete specification of the reference test procedure, including the referenced year version of the test procedure.

[b] IPLVs and part load rating conditions are only applicable to equipment with capacity modulation.

[c] Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

[d] Single-phase, air-cooled air-conditioners <65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

[e]As granted by U.S. Department of Energy letter of exception, specific to individual companies, SDHV products without a letter of exception shall have the same efficiency as air-cooled air-conditioners.

TABLE 503.2.3(2)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Cooled (Cooling mode)	<65,000 Btu/h[d]	Split System	13.0 SEER	AHRI 210/240
		Single Package	13.0 SEER	
	≥65,000 Btu/h and <135,000 Btu/h	Split System and Single Package	11.0 EER[c]	
	≥135,000 Btu/h and <240,000 Btu/h	Split System and Single Package	10.6 EER[c]	AHRI 340/360
	≥240,000 Btu/h	Split System and Single Package	9.5 EER[c], 9.2 IPLV[c]	
Through-the Wall, Air-cooled cooling mode	<30,000 Btu/h[d]	Split System	12.0 SEER	AHRI 210/240
		Single Package	12.0 SEER	
Small-Duct High-Velocity, Air cooled	<65,000 Btu/h[c]	Split system or Single Package	11.0 SEER	
Space constrained products, air conditioners	<65,000 Btu/h[c]	Split system or Single Package	12.0 SEER[e]	
Air CWater Source (Cooling Mode)	<17,000 Btu/h	86°F entering water	11.2 EER	AHRI/ASHRAE 13256-1
	≥17,000 Btu/h and <135,000 Btu/h	86°F entering water	12.0 EER	
Groundwater Source (cooling mode)	<135,000 Btu/h	59°F entering water	16.2 EER	
Ground source (Cooling mode)	<135,000 Btu/h	77°F entering water	13.4 EER	
Air cooled (Heating mode)	<65,000 Btu/h[d] (Cooling capacity)	Split system	7.7 HSPF	AHRI 210/240
		Single package	7.7 HSPF	
	≥65,000 Btu/h and < 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb Outdoor air	3.3 COP	
	≥135,000 Btu/h (Cooling capacity)	47°F db/43°F wb Outdoor air	3.2 COP	AHRI 340/360

Through the wall (Air cooled, heating mode) Wa	<30,000 Btu/h	Split system	7.4 HSPF	AHRI 210/240
		Single package	7.4 HSPF	
Water source (Heating mode)	<135,000 Btu/h (Cooling capacity)	68°F entering water	4.2 COP	AHRI/ASHRAE 13256-1
Groundwater source (Heating mode)	<135,000 Btu/h (Cooling capacity)	50°F entering water	3.6 COP	AHRI/ASHRAE 13256-1
Ground source (Heating mode)	<135,000 Btu/h (Cooling capacity)	32°F entering water	3.1 COP	AHRI/ASHRAE 13256-1

For SI: °C – [(°F) – 32]/1.8 British thermal unit per hour – 0.2931 W. db = dry-bulb temperature, °F wb = wet-bulb temperature, °F

[a] Chapter 6 contains a complete specification of the reference test procedure, including the referenced year version of the test procedure.

[b] IPLVs and part load rating conditions are only applicable to equipment with capacity modulation.

[c] Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

[d]Single-phase, air-cooled air-conditioners <65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

[e]As granted by U.S. Department of Energy letter of exception, specific to individual companies, SDHV products without a letter of exception shall have the same efficiency as air-cooled air-conditioners.

TABLE 503.2.3(3)
PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
PTAC (Cooling mode) New construction	All capacities	95°F db outdoor air	12.5 – (0.213 x Cap/1000) EER	AHRI 310/380
PTAC (Cooling mode) Replacements[c]	All capacities	95°F db outdoor air	10.9 – (0.213 x Cap/1000) EER	
PTHP (Cooling mode) New construction	All capacities	95°F db outdoor air	12.3 – (0.213 x Cap/1000) EER	
PTHP (Cooling mode) Replacements[c]	All capacities	95°F db outdoor air	10.8 – (0.213 x Cap/1000) EER	
PTHP (Heating mode) New construction	All capacities	---	3.2 – (0.026 x Cap/1000) COP	
PTHP (Heating mode) Replacements[c]	All capacities	---	2.9 – (0.026 x Cap/1000) COP	

For SI: °C – [(°F) – 32]/1.8 British thermal unit per hour – 0.2931 W. db = dry-bulb temperature, °F wb = wet-bulb temperature, °F

[a] Chapter 6 contains a complete specification of the reference test procedure, including the referenced year version of the test procedure.

[b] Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

[c] Replacement units must be factory labeled as follow: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement

efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) high and less than 542 inches (1067 mm) wide.

TABLE 503.2.3(4)
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS
Minimum Efficiency Requirements

Equipment Type	Size Category	Subcategory or Rating Condition	Minimum Efficiency[d,e]	Test Procedure[a]
Warm Air Furnace, Gas-Fired	<225,000 Btu/h	---	78% AFUE or 80% E_t[c]	DOE 10 CFR, Part 430 or ANSI Z 21.47
	≥225,000 Btu/h	Maximum Capacity[c]	80% E_c[f]	ANSI Z21.47
Warm Air Furnace, Oil-Fired	<225,000 Btu/h	---	78% AFUE or 80% E_t[c]	DOE 10 CFR, Part 430 or UL 727
	≥225,000 Btu/h	Maximum Capacity[b]	81% E_t[g]	UL 727
Warm Air Duct Furnaces, Gas-Fired	All Capacities	Maximum Capacity[b]	80% E_c	ANSI Z83.8
Warm Air Unit Heaters, Gas-Fired	All Capacities	Maximum Capacity[b]	80% E_c	ANSI Z83.8
Warm Air Unit Heaters, Oil-Fired	All Capacities	Maximum Capacity[b]	80% E_c	UL 731

For SI: 1 British thermal unit per hour = 0.2931 W.
[a] Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] Minimum and maximum ratings as provided for and allowed by the unit's controls.
[c] Combination units not covered by NAECA (3 phase power or cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating.
[d] E_t = Thermal efficiency. See test procedure for detailed discussion
[e] E_c= Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
[f] E_c = Combustion efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[g] E_t = Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

TABLE 503.2.3(5)
BOILERS, GAS- AND OIL-FIRED,
Minimum Efficiency Requirements

Equipment Type[4]	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency[b]	Test Procedure[2]
Boilers, Gas-Fired	<300,000 Btu/h	Hot water	80% AFUE	DOE 10 CFR Part 430
		Steam	75% AFUE	
	≥300,000 Btu/h and ≤2,500,000	Maximum Capacity[b]	75% E_t (See Note c,d)	DOE 10 CFR Part 431
	>2,500,000 Btu/h[f]	Hot Water	80% E_c (See Note c,d)	
	>2,500,000 Btu/h[4]	Steam	80% E_c (See Note c,d)	
Boilers, Oil-Fired	<300,000 Btu/h		80% AFUE	DOE 10 CFR Part 430
	>300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity[3]	78% E_t and 83% E_c (See Note c,d)	DOE 10 CFR Part 431

	>2,500,000 Btu/h[4]	Hot Water	83% E_c (See Note c,d)	
	>2,500,000 Btu/h[4]	Steam	83% E_c (See Note c,d)	
Oil-Fired (Residual)	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity[3]	78% E_t and 83% E_c (See Note c,d)	DOE 10 CFR Part 431
	>2,500,000 Btu/h[a]	Hot Water	83% E_c (See Note c,d)	
		Steam	83% E_c (See Note c,d)	

For SI: 1 British thermal unit per hour = 0.2931 W.

[a] Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

[b] Minimum and maximum ratings as provided for and allowed by the unit's controls.

[e] E_c= Combustion efficiency (100% less flue losses). See reference document for detailed discussion.

[d] E_t = thermal efficiency. See reference documents for detailed information.

[e] Alternative test procedures used at the manufacturer's option are ASME PTC-4.1 for units greater than 5,000,000 Btu/h input, or ANSI Z21.13 for units greater than or equal to 300,000 Btu/h and less than or equal to 2,500,000 Btu/h input.

[f] These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers, and to all package boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

TABLE 503.2.3(6)
CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Minimum Efficiency[b]	Test Procedure[a]
Condensing units, air cooled	**≥ 135,000 Btu/h**	**10.1 EER, 11.2 IPLV**	**AHRI 365**
Condensing units, water or evaporatively cooled	**≥ 135,000 Btu/h**	**13.1 EER, 13.1 IPLV**	

For SI: 1 British tehermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. IPLVs sare only applicable to equipment with capacity modulation.

TABLE 503.2.3(7)
WATER CHILLING PACKAGES, EFFICIENCY REQUIREMENTS[a]

Equipment Type	Size Category	Units	Path A		Path B		Test Procedure
			Full Load	IPLV	Full Load	IPLV	AHRI 550/590
Air-cooled chillers	< 150 tons	EER	≥ 9.562	≥ 12.500	NA[d]	NA[d]	
	≥ 150 tons	EER	≥ 9.562	≥ 12.750	NA[d]	NA[d]	
Air cooled without condenser, electrical operated	All capacities	EER	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water cooled, electrically operated, reciprocating	All capacities	kW/ton	Reciprocating units must comply with water cooled positive displacement efficiency requirements.				
	< 75 tons	kW/ton	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	

Water cooled, electrically operated, positive displacement	≥ 75 tons and < 150 tons	kW/ton	≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	
	≥ 300 tons	kW/ton	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490	
Water cooled, electrically operated, centrifugal	< 300 tons	kW/ton	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	≥ 600 tons	kW/ton	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption single effect	All capacities	COP	≥ 0.600	NR[e]	NA[d]	NA[d]	AHRI 560
Water-cooled, absorption single effect	All capacities	COP	≥ 0.700	NR[e]	NA[d]	NA[d]	
Absorption double effect indirect-fired	All capacities	COP	≥ 1.000	≥ 1.050	NA[d]	NA[d]	
Absorption double effect direct-fired	All capacities	COP	≥ 1.000	≥ 1.000	NA[d]	NA[d]	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is < 40°F.

b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or B.

d. NA means that this requirement is not applicable and cannot be used for compliance.

e. NR means that there are no minimum requirements for this category.

503.2.4 HVAC system controls. Each heating and cooling system shall be provided with thermostatic controls as required in Section 503.2.4.1, 503.2.4.2, 503.2.4.3, 503.2.4.4, 503.4.1, 503.4.2, 503.4.3 or 503.4.4.

503.2.4.1 Thermostatic controls. The supply of heating and cooling energy to each zone shall be controlled by individual thermostatic controls capable of responding to temperature within the zone. ~~Where humidification or dehumidification or both is provided, at least one humidity control device shall be provided for each humidity control system.~~ For the purposes of this section, a dwelling unit shall be permitted to be considered a single zone.

Exception: Independent perimeter systems that are designed to offset only building envelope heat losses or gains or both serving one or more perimeter zones also served by an interior system provided:

1. The perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one orientation (within +/- 45 degrees) (0.8 rad) for more than 50 contiguous feet (15.2 m); and
2. The perimeter system heating and cooling supply is controlled by a thermostat(s) located within the zone(s) served by the system.

503.2.4.1.1 Heat pump supplementary heat. Heat pumps having supplementary electric resistance heat shall have controls that, except during defrost, prevent supplementary heat operation when the heat pump can meet the heating load.

503.2.4.2 Set point overlap restriction. Where used to control both heating and cooling, *zone* thermostatic controls shall provide a temperature range or deadband of at least 5°F (2.8°C) within which the supply of heating and cooling energy to the zone is capable of being shut off or reduced to a minimum.

Exception:

1. Thermostats requiring manual changeover between heating and cooling modes.

503.2.4.3Off-hour controls. Each zone shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

Exceptions:

1. Zones that will be operated continuously
2. Zones with a full HVAC load demand not exceeding 6,800 Btu/h (2 kW) and having a readily accessible manual shutoff switch.

503.2.4.3.1 Thermostatic setback capabilities. Thermostatic setback controls shall have the capability to set back or temporarily operate the system to maintain zone temperatures down to 55°F (13°C) or up to 85°F (29°C).

503.2.4.3.2 Automatic setback and shutdown capabilities. Automatic time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for at least 10 hours. Additionally, the controls shall have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer capable of being adjusted to operate the system for up to 2 hours; ~~or~~ an occupancy sensor~~.~~ or an interlock to a security system that shuts the system off when the security system is activated.

Exception: Residential occupancies may use controls that can start and stop the system under two different time schedules per week.

503.2.4.3.3 Humidistatic control. Where humidification or dehumidification or both is provided, the following shall be met:

1. At least one humidity control device shall be provided for each humidity control system.

2. Controls shall be provided capable of preventing simultaneous operation of humidification and dehumidification equipment. **[ASHRAE 6.4.3.7; 13-407.AB.2.4.3]**

Exceptions:

1. Zones served by desiccant systems, used with direct evaporative cooling in series.
2. Systems serving zones where specific humidity levels are required, such as computer rooms, museums and hospitals, as approved by the building official.

503.2.4.4 Shutoff damper controls. Both outdoor air supply and exhaust ducts shall be equipped with ~~motorized~~ dampers that will automatically shut when the systems or spaces served are not in use.

~~**Exceptions:**~~

~~1. Gravity dampers shall be permitted in buildings less than three stories in height.~~

~~2. Gravity dampers shall be permitted for buildings of any height located in Climate Zones 1, 2 and 3.~~

~~3. Gravity dampers shall be permitted for outside air intake or exhaust airflows of 300 cfm (0.14 m^3/s) or less.~~

503.2.4.5 ~~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 (10°C) and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible.~~ **Freeze Protection**. **[ASHRAE 6.4.3.8; 13-408.AB.2.3]** Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls capable of shutting off the systems when outside air temperatures are above 40°F (4°C) or when the conditions of the protected fluid will prevent freezing.

503.2.4.6 [13-407.AB.2.5.2] Air distribution system controls. Individual heating and cooling air distribution systems with a total design supply air capacity exceeding 10,000 cfm (5 m^3/S), served by one or more supply fans, shall have optimum start controls. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint and the amount of time prior to scheduled occupancy.

503.2.5 Ventilation. Ventilation, either natural or mechanical, shall be provided in accordance with Chapter 4 of the *Florida Building Code, ~~International~~ Mechanical ~~Code.~~* Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by Chapter 4 of the *Florida Building Code, ~~International~~ Mechanical ~~Code~~.*

503.2.5.1 Demand controlled ventilation. Demand control ventilation (DCV) is required for spaces larger than 500 ft^2 (50m^2) and with an average occupant load of 40 people per 1000 ft^2 (93 m^2) of floor area (as established in Table 403.3 of the *Florida Building Code, ~~International~~ Mechanical ~~Code~~*) and served by systems with one or more of the following:

1. An air-side economizer;
2. Automatic modulating control of the outdoor air damper; or
3. A design outdoor airflow greater than 3,000 cfm (1400 L/s).

Exceptions:

1. Systems with energy recovery complying with Section 503.2.6.
2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.
3. System with a design outdoor airflow less than 1,200 cfm (600 L/s).
4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (600 L/s).

503.2.5.2 Outdoor air intakes and exhaust openings. [IECC was 502.4.5]

503.2.5.2.1 Stair and elevator shaft vents. Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of being automatically closed during normal building operation and are interlocked to open as required by fire and smoke detection systems.

Exception: Gravity (nonmotorized) dampers are permitted to be used in buildings less than three stories in height above grade. **[Exception** is not given by ASHRAE]

503.2.5.2.2 Exhaust hoods

503.2.5.2.2.1 Kitchen hoods. Individual kitchen exhaust hoods larger than 5,000 cfm shall be provided with makeup air sized for at least 50% of exhaust air volume that is

1. unheated or heated to no more than 60°F and

2. uncooled or cooled without the use of mechanical cooling.

[ASHRAE language. Replace FL Non-residential kitchen spaces?]

Exceptions:

1. Where hoods are used to exhaust ventilation air that would otherwise exfiltrate or be exhausted by other fan systems.
2. Certified grease extractor hoods that require a fact velocity no greater than 60 fpm.

OR

503.2.5.2.2.1 Non-residential kitchen spaces. Non-residential kitchen space and areas in dining rooms or open malls where a kitchen exhaust hood is required by NFPA 96 shall comply with the following requirements:

1. Be designed with an exhaust air and make up air balance such that the space is never under a positive pressure, and never under a negative pressure exceeding 0.02" w.g. relative to all indoor spaces surrounding the kitchen space, during all cooking hours.
2. All exhaust and makeup air system components (fans, dampers, etc.) shall be interlocked in such a way that the balance prescribed in #1 above is maintained throughout all cooking hours, and all variations of cooking operations.

503.2.5.2.2.2 Fume hoods. Buildings with fume hood systems having a total exhaust rate greater than 15,000 cfm shall include at least one of the following features:

1. Variable air volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.
2. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (-17°C) below room set point, cooled to no cooler than 3°F (-16°C) above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
3. Heat recovery systems to precondition makeup air from fume hood exhaust in accordance with Section 503.2.6 (Exhaust Air Energy Recovery) without using any exception.

503.2.5.3 Gravity Hoods, Vents, and Ventilators. [**13-409.AB.3.2; ASHRAE 6.3.4.2**] All outdoor air supply and exhaust hoods, vents, and ventilators shall be equipped with ~~motorized~~ dampers that will automatically shut when the spaces served are not in use.

Exceptions:

~~1. Gravity (non-motorized) dampers are acceptable in buildings less than three stories in height above grade and for buildings of any height located in climates with less than 2700 HDD65.~~

~~2.~~ Ventilation systems serving unconditioned spaces.

503.2.5.4 ~~503.2.4.4~~ Shutoff damper controls. [FL 13-409.AB.3.3; ASHRAE 6.3.4.3] Both outdoor air supply and exhaust ducts shall be equipped with ~~motorized~~ dampers that will automatically shut when the systems or spaces served are not in use. Ventilation outside air dampers shall be capable of automatically shutting off during preoccupancy building warmup, cooldown, and setback, except when ventilation reduces energy costs (e.g., night purge) or when ventilation must be supplied to meet code requirements.

Exceptions:

1. Gravity dampers shall be permitted in buildings less than three stories in height.

2. Gravity dampers shall be permitted for buildings of any height located in Climate Zones 1, 2 and 3.

3. Gravity dampers shall be permitted for outside air intake or exhaust airflows of 300 cfm (0.14 m^3/s) or less.

503.2.5.4.1 Damper leakage [FL 13-409.AB.3.3.1; IECC 502.4.5]. Motorized dampers Where outdoor air supply and exhaust air dampers are required by Section 13-409.AB.3, they shall have a maximum leakage rate at 1 in. w.g. of 4 cfm per square foot of damper area for motorized dampers when tested in accordance with AMCA Standard 500 as indicated in Table 13-409.AB.3.3.1.

502.4.5 Outdoor air intakes and exhaust openings. Stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage-rated damper with a maximum leakage rate of 4 cfm per square foot (6.8 L/s · C m^2) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance with AMCA 500D.

Exception: Gravity (nonmotorized) dampers are permitted to be used in buildings less than three stories in height above grade.

Table 13-409.AB.3.3.1
Maximum Damper Leakage

Maximum Damper Leakage at 1.0 in. w.g. cfm per ft^2 of damper area	
Motorized	**Non-motorized**
4	Not allowed[a]

503.2.6 Exhaust air energy recovery for cooling systems Energy recovery ventilation systems. Individual cooling fan systems that have both a design supply air capacity of 5,000 cfm (2.36 m^3/s) or greater and a minimum outside air supply of 70 percent or greater of the design supply air quantity shall have an energy recovery system that provides a change in the enthalpy of the outdoor air supply of 50 percent or more of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the energy recovery system to permit cooling with outdoor air where cooling with outdoor air is required.

Exception: An energy recovery ventilation system shall not be required in any of the following conditions:

1. Where energy recovery systems are prohibited by the *Florida Building Code, International Mechanical Code*.
   - 1.1 Systems exhausting toxic, flammable, paint or corrosive fumes or dust.
   - 1.2 Commercial kitchen hoods (grease) used for collecting and removing grease vapors and smoke.
2. Laboratory fume hood systems that include at least one of the following features:
   - 2.1. Variable-air-volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.
   - 2.2. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (1.1°C) below room setpoint, cooled to no cooler than 3°F (1.7°C) above room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
   - 2.3. Where the largest exhaust source is less than 75 percent of the design outdoor airflow.
3. Systems serving spaces that are not cooled and are heated to less than 60°F (15.5°C).

4. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.

5. Heating systems in climates with less than 3,600 HDD.

6. Cooling systems in climates with a 1-percent cooling design wet-bulb temperature less than 64°F (18°C).

[All of Florida has a 1% wet bulb temperature >64°F.]

4 7. Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil.

503.2.7 Duct and plenum insulation, construction and sealing.

503.2.7.1 Insulation.

503.2.7.1.1 Insulation required. All supply and return air ducts and plenums shall be insulated to the levels shown in Table 503.2.7.1 with a minimum of R-5 insulation when located in unconditioned spaces and a minimum of R-8 insulation when located outside the building. When located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-8 insulation.

Exceptions:

1. When located within equipment.
2. When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C).
3. For runouts less than 10 feet (3048 mm) in length to air terminals or air outlets, the rated R-value of insulation need not exceed R-5.
4. Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas exceeding 5 square feet (.46 m^2) need not exceed R-2; those 5 square feet (.46 m^2) or smaller need not be insulated.
5. Return air ducts meeting all the requirements for building cavities which will be used as return air plenums.

~~All ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the *International Mechanical Code*.~~

503.2.7.1.2 Insulation protection. Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance, and wind, but not limited to the following:

1. Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.
2. Insulation covering cooling ducts located outside the conditioned space shall include a vapor retardant located outside the insulation (unless the insulation is inherently vapor retardant), all penetrations and joints of which shall be sealed.

503.2.7.1.3 Condensation Control. Additional insulation with vapor barrier shall be provided where the minimum duct insulation requirements of Section 503.2.7.1.1 are determined to be insufficient to prevent condensation.

TABLE 503.2.7.1
MINIMUM DUCT INSULATION R-VALUES,
Heating and Cooling Supply and Return Ducts

Location	Supply Duct	Return Duct
Exterior of building	R-8	R-5
Ventilated Attic	R-6	R-5
Unvented attic above insulated ceiling	R-6	R-5
Unvented attic with roof insulation	R-5	None
Unconditioned spaces[1]	R-5	R-5
Indirectly conditioned spaces[2]	None	None
Conditioned spaces	None	None
Buried	R-5	None

[1] Includes crawl spaces, both ventilated and non-ventilated.
[2] Includes return air plenums with or without exposed roofs above.

503.2.7.2~~1~~ Duct construction. All ducts, air handlers, filter boxes, building cavities, mechanical closets and enclosed support platforms that form the primary air containment passageways for air distribution systems shall be considered ducts or plenum chambers and ~~Ductwork~~ shall be constructed and erected in accordance with Table 503.2.7.2 and with Chapter 6 of the *Florida Building Code, Mechanical* ~~*International Mechanical Code*~~. Ducts shall be constructed, braced, reinforced and installed to provide structural strength and durability. All transverse joints, longitudinal seams and fitting connections shall be securely fastened in accordance with the applicable standards of this section.

~~**503.2.7.1 Duct construction.**~~

~~**503.2.7.2.1.1 Low-pressure duct systems.** All longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches w.g. (500 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic plus embedded fabric systems or tapes installed in accordance with the manufacturer's installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *Florida Building Code, International Mechanical Code*.~~

~~**Exception:** Continuously welded and locking-type longitudinal joints and seams on ducts operating at static pressures less than 2 inches w.g. (500 Pa) pressure classification.~~

~~**503.2.7.1.2 Medium-pressure duct systems.** All ducts and plenums designed to operate at a static pressure greater than 2 inches w.g. (500 Pa) but less than 3 inches w.g. (750 Pa) shall be insulated and sealed in accordance with Section 503.2.7. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *Florida Building Code, International Mechanical Code*.~~

~~**503.2.7.1.3 High-pressure duct systems.** Ducts designed to operate at static pressures in excess of 3 inches w.g. (746 Pa) shall be insulated and sealed in accordance with Section 503.2.7. In addition, ducts and plenums shall be leak-tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual* with the rate of air leakage (*CL*) less than or equal to 6.0 as determined in accordance with Equation 5-2.~~

~~$$CL = F \_ P_{0.65}$$ **(Equation 5-2)**~~

~~where:~~

~~*F* = The measured leakage rate in cfm per 100 square feet of duct surface.~~

~~*P* = The static pressure of the test.~~

~~Documentation shall be furnished by the designer demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.~~

503.2.7.3 Sealing, general ~~(Mandatory)~~. All ducts, air handlers, filter boxes, building cavities, mechanical closets and enclosed support platforms that form the primary air containment passageways for air distribution systems shall be sealed in accordance with the applicable criteria of this section and Table 503.2.7.2.

503.2.7.3.1 Mechanical fastening. All joints between sections of air ducts and plenums, between intermediate and terminal fittings and other components of air distribution systems, and between subsections of these components shall be mechanically fastened to secure the sections independently of the closure system(s).

503.2.7.3.2 Sealing. Air distribution system components shall be sealed with approved closure systems.

503.2.7.3.3 Space provided. Sufficient space shall be provided adjacent to all mechanical components located in or forming a part of the air distribution system to assure adequate access for: (1) construction and sealing in accordance with the requirements of Section 503.2.7; (2) inspection; and (3) cleaning and maintenance. A minimum of 4 inches (102 mm) is considered sufficient space around air-handling units.

Exception: Retrofit or replacement units not part of a renovation.

503.2.7.3.4 Product application. Closure products shall be applied to the air barriers of air distribution system components being joined in order to form a continuous barrier or they may be applied in accordance with the manufacturer's instructions or appropriate industry installation standard where more restrictive.

503.2.7.3.5 Surface preparation. The surfaces upon which closure products are to be applied shall be clean and dry in accordance with the manufacturer's installation instructions.

503.2.7.3.6 Approved mechanical attachments. Approved mechanical attachments for air distribution system components include screws, rivets, welds, interlocking joints crimped and rolled, staples, twist in (screw attachment), and compression systems created by bend tabs or screw tabs and flanges or by clinching straps. Mechanical attachments shall be selected from Table 503.2.7.2 to be appropriate to the duct system type.

503.2.7.3.7 Approved closure systems. The following closure systems and materials are approved for air distribution construction and sealing for the applications and pressure classes shown in Table 503.2.7.2.

1. Metal closures.
   a. Welds applied continuously along metal seams or joints through which air could leak.
   b. Snaplock seams, and grooved, standing, double-corner, single-corner and Pittsburgh-lock seams, as defined by SMACNA, as well as all other rolled mechanical seams. All seams shall be rolled or crimped
2. Gasketing, which achieves a 25/50 flame spread/smoke-density-development rating under ASTM E 84 or UL 723, provided that it is used only between mated surfaces which are mechanically fastened with sufficient force to compress the gasket and to fill all voids and cracks through which air leakage would otherwise occur.
3. Mastic closures. Mastics shall be placed over the entire joint between mated surfaces. Mastics shall not be diluted. Approved mastics include the following:

a. Mastic or mastic-plus-embedded fabric systems applied to fibrous glass ductboard that are listed and labeled in accordance with UL 181A, Part III.

b. Mastic or mastic-plus-embedded fabric systems applied to nonmetal flexible duct that are listed and labeled in accordance with UL 181B, Part II.

c. Mastic ribbons, which achieve a 25/50 flame spread/smoke density development rating under ASTM E 84 or UL 723, provided that they may be used only in flange-joints and lap-joints, such that the mastic resides between two parallel surfaces of the air barrier and that those surfaces are mechanically fastened.

4. Tapes. Tapes shall be applied such that they extend not less than 1 inch onto each of the mated surfaces and shall totally cover the joint. When used on rectangular ducts, tapes shall be used only on joints between parallel rigid surfaces and on right angle joints. Approved tapes include the following:

a. Pressure-sensitive tapes.

1) Pressure-sensitive tapes applied to fibrous glass ductboard that are listed and labeled in accordance with UL 181A, Part I.

2) Pressure-sensitive tapes applied to nonmetal flexible duct that are listed and labeled in accordance with UL 181B, Part I.

b. Heat-activated tapes applied to fibrous glass ductboard that are listed and labeled in accordance with UL 181A, Part II.

5. Aerosol sealant. Such sealants shall be installed by manufacturer-certified installers following manufacturer instructions and shall achieve 25/50 flame spread/smoke-density-development ratings under ASTM E 84 or UL 723.

503.2.7.4 Cavities of the Building Structure. Cavities in framed spaces, such as dropped soffits and walls, shall not be used to deliver air from or return air to the conditioning system unless they contain an air duct insert which is insulated in accordance with Section 503.2.7.1 and constructed and sealed in accordance with the requirements of Section 503.2.7.2.2 appropriate for the duct materials used.

Exception: Return air plenums beneath a roof deck that is insulated to at least R-19.

503.2.7.5 Air distribution system sizing and design. All air distribution systems shall be sized and designed in accordance with recognized engineering standards such as ACCA Manual D or other standards based on the following:

1. Calculation of the supply air for each room shall be based on the greater of the heating load or sensible cooling load for that room.

2. Duct size shall be determined by the supply air requirements of each room, the available static pressure and the total equivalent length of the various duct runs.

3. Friction loss data shall correspond to the type of material used in duct construction.

503.2.7.6 Air-handling units. Air-handling units shall not be allowed in attics.

TABLE 503.2.7.2
DUCT SYSTEM CONSTRUCTION AND SEALING

DUCT TYPE/CONNECTION	SEALING REQUIREMENTS	MECHANICAL ATTACHMENT	TEST STANDARD
Metal duct, rigid and flexible			
Pressures less than 1-inch water gauge	Closure systems as described in Section 503.2.7.3: 1. Continuous welds. 2. Snaplock seams, and grooved, standing, double-corner, single-corner and Pittsburgh-lock seams and all other rolled mechanical seams.	Mechanical attachments approved: 1. Continuous welds. 2. Snaplock seams, and grooved, standing, double-corner, single-corner and Pittsburgh-lock seams and all other rolled mechanical seams.	SMACNA HVAC Air Duct Leakage Test Manual

	3. Mastic, mastic-plus-embedded fabric, or mastic ribbons. 4. Gaskets. 5. Pressure-sensitive tape.		
Pressures 1-inch water gauge or greater	Closure systems as described in Section 503.2.7.3: 1. Continuous welds. 2. Mastic or mastic-plus-embedded fabric systems. 3. Gaskets.	Mechanical attachments approved: Continuous welds.	SMACNA HVAC Air Duct Leakage Test Manual
High pressure duct systems designed to operate at pressures greater than 3-inch water gauge (4-inch water gauge pressure class)	Shall be tested in accordance with the standard . The tested duct leakage class, at a test pressure equal to the design duct pressure class rating, shall be equal to or less than Leakage Class 6. Leakage testing may be limited to representative sections of the duct system but in no case shall such tested sections include less than 25 percent of the total installed duct area for the designated pressure class.		SMACNA HVAC Air Duct Leakage Test Manual
Fibrous glass duct, rigid.	All joints, seams and duct wall penetrations between sections of duct and between duct and other distribution system components shall be sealed with closure systems as described in Section 503.2.7.3: 1. Heat-activated tapes. 2. Pressure-sensitive tapes. 3. Mastics or mastic-plus-embedded fabric systems.	Mechanically fastened per standard to secure the sections independent of the closure system(s). Attachments of ductwork to air-handling equipment shall be by mechanical fasteners. Where access is limited, two fasteners on one side shall be acceptable.	NAIMA Fibrous Glass Duct Construction Standards. UL 181 UL 181A
Flexible duct systems, nonmetal.	All duct collar fittings shall have a minimum 5/8 inch (16 mm) integral flange for sealing to other components and a minimum 3-inch (76 mm) shaft for insertion into the inner duct core. Flexible ducts having	Flexible nonmetal ducts shall be joined to all other air distribution system components by either terminal or intermediate fittings. Flexible ducts shall be configured and supported so as to prevent the use	UL 181 UL 181B

	porous inner cores shall not be used. **Exception:** Ducts having a nonporous liner between the porous inner core and the outer jacket. Fastening and sealing requirements shall be applied to such intermediate liners.	of excess duct material, prevent duct dislocation or damage, and prevent constriction of the duct below the rated duct diameter in accordance with the following requirements: 1. Ducts shall be installed fully extended. The total extended length of duct material shall not exceed 5 percent of the minimum required length for that run. 2. Bends shall maintain a center line radius of not less than one duct diameter. 3. Terminal devices shall be supported independently of the flexible duct. 4. Horizontal duct shall be supported at intervals not greater than 5 feet (1524 mm). Duct sag between supports shall not exceed ½ inch (12.7 mm) per foot of length. Supports shall be provided within 1½ feet (38 mm) of intermediate fittings and between intermediate fittings and bends. Ceiling joists and rigid duct or equipment may be considered to be supports. 5. Vertical duct shall be stabilized with support straps at intervals not greater than 6 feet (1829 mm). 6. Hangers, saddles and other supports shall meet the duct manufacturer's recommendations	

		and shall be of sufficient width to prevent restriction of the internal duct diameter. In no case shall the material supporting flexible duct that is in direct contact with it be less than 1½ inches (38 mm) wide.	
Duct core to duct fitting	The reinforced lining shall be sealed to the duct fitting using one of the following sealing materials which conforms to the approved closure and mechanical attachment requirements of Section 403.2.7.3.7: 1. Gasketing. 2. Mastic, mastic-plus-embedded fabric, or mastic ribbons. 3. Pressure-sensitive tape. 4. Aerosol sealants, provided that their use is consistent with UL 181.	The reinforced core shall be mechanically attached to the duct fitting by a drawband installed directly over the wire-reinforced core and the duct fitting. The duct fitting shall extend a minimum of 2 inches (51 mm) into each section of duct core. When the flexible duct is larger than 12 inches (303 mm) in diameter or the design pressure exceeds 1-inch water gauge, the drawband shall be secured by a raised bead or indented groove on the fitting.	
Duct outer jacket to duct collar fitting	The outer jacket of a flexible duct section shall be secured at the juncture of the air distribution system component and intermediate or terminal fitting in such a way as to prevent excess condensation. The outer jacket of a flexible duct section shall not be interposed between the flange of the duct fitting and the flexible duct, rigid fibrous glass duct board, or sheet metal to which it is mated.		
Duct collar fitting to rigid duct	The duct collar fitting's integral flange shall be sealed to the rigid duct board or sheet metal using one of the following closure systems/materials which conforms to the approved closure and	The duct collar fitting shall be mechanically attached to the rigid duct board or sheet metal by appropriate mechanical fasteners, either screws, spin-in flanges, or dovetail flanges.	

	mechanical attachment standards of Section 503.2.7.3: 1. Gasketing. 2. Mastic or mastic-plus-embedded fabric systems. 3. Mastic ribbons when used to attach a duct collar to sheet metal. 4. Pressure-sensitive tape. 5. Aerosol sealants, provided that their use is consistent with UL 181.		
Terminal and intermediate fittings. **Fittings and joints between dissimilar duct types** **Terminal fittings and air ducts to building envelope components**	Approved closure systems shall be as designated by air distribution system component material type in Section 503.2.7.3. **Exception:** When the components of a joint are fibrous glass duct board and metal duct, including collar fittings and metal equipment housings, the closure systems approved for fibrous glass duct shall be used. Terminal fittings and air ducts which penetrate the building envelope shall be mechanically attached to the structure and sealed to the envelope component penetrated and shall use one of the following closure systems/materials which conform to the approved closure and mechanical application requirements of Section 503.2.7.3: 1. Mastics or mastic-plus-embedded fabrics. 2. Gaskets used in terminal fitting/grille assemblies which compress the gasket material between the fitting and the wall, ceiling or floor		

	sheathing.		
Air-handling units.	Air-handling units located outside the conditioned space shall be sealed using approved closure systems described in Section 503.2.7.3	All air-handling units shall be mechanically attached to other air distribution system components.	
Return plenums.	Building cavities which will be used as return air plenums shall be lined with a continuous air barrier made of durable nonporous materials. All penetrations to the air barrier shall be sealed with a suitable long-life mastic material. **Exception:** Surfaces between the plenum and conditioned spaces from which the return/mixed air is drawn.		
Mechanical closets.	All joints between the air barriers of walls, ceiling, floor and door framing and all penetrations of the air barrier shall be sealed to the air barrier with approved closure systems. Through-wall, through-floor and through-ceiling air passageways into the closet shall be framed and sealed to form an air-tight passageway. **Exception:** Air passageways into the closet from conditioned space that are specifically designed for return air flow. The following air barriers are approved for use in mechanical closets: 1. One-half-inch-thick (12.7 mm) or greater gypsum wallboard, taped and sealed. 2. Other panelized materials having inward facing surfaces with an air porosity no greater than that of a duct product meeting Section 22 of UL 181 which are sealed on all interior surfaces to create a	The following closure systems are approved for use in mechanical closets: 1. Gypsum wallboard joint compound over taped joints between gypsum wallboard panels. 2. Sealants complying with the product and application standards of Table 503.2.7.2 for fibrous glass ductboard. 3. A suitable long-life caulk or mastic compliant with the locally adopted mechanical code for all applications.	

	continuous air barrier.		
Enclosed support platforms in unconditioned spaces.	Enclosed support platforms located between the return air inlet(s) from conditioned space and the inlet of the air-handling unit or furnace, shall contain a duct section constructed entirely of rigid metal, rigid fibrous glass duct board, or flexible duct which is constructed and sealed according to the respective requirements of Section 503.2.7.2 and insulated according to the requirements of Section 503.2.7.1. No portion of the building structure, including adjoining walls, floors and ceilings, shall be in contact with the return air stream or function as a component of this duct section		

503.2.8 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 503.2.8.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and 840, respectively.
3. Piping that conveys fluids that have a design operating temperature range between 55°F (13°C) and 105°F (41°C).
4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power (such as roof and condensate drains, domestic cold water supply, natural gas piping, or refrigerant liquid piping) or where heat gain or heat loss will not increase energy usage.
5. Runout piping not exceeding 4 feet (1219 mm) in length and 1 inch (25 mm) in diameter between the control valve and HVAC coil when located in conditioned spaces.
6. Pipe unions in heating systems (steam, steam condensate, and hot water).

TABLE 503.2.8
MINIMUM PIPE INSULATION (in.)[1]

Fluid Design Operating Temperature Range (°F)	**Insulation Conductivity**		**Nominal Pipe or Tube Size (in.)**				
	Conductivity Btu in/(h ft^2 .°F)	**Mean Temperature Rating**	**<1**	**1-1 ½ -**	**1 ½ to 4**	**4to <8**	**>8**
Heating Systems (Steam Condensate, and Hot Water)[2,3]							
>350	0.32 - 0.34	250	2.5	3.0	3.0	4.0	4.0

251 – 350	0.29 - 0.32	200	1.5	2.5	3.0	3.0	3.0
201 – 250	0.27 - 0.30	150	1.5	1.5	2.0	2.0	2.0
141 – 200	0.25 - 0.29	125	1.01	1.0	1.0	1.5	1.5
105 – 140	0.22-0.28	100	0.5	0.5	1.0	1.0	1.0
Domestic and Service Hot Water Systems[3]							
>105	0.22-0.28	100	0.5	0.5	1.0	1.0	1.0
Cooling Systems (Chilled Water, Brine, and Refrigerant)[4]							
40 – 60	0.22-0.28	100	0.5	1.0	1.0	1.0	1.0
<40	0.22-0.28	100	0.5	1.5	1.5	1.0	1.5

[1]For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T=r(1+t/r)^{K/k} - 1$

Where T= minimum insulation thickness (in.), r=actual outside radius of pipe (in.), t=insulation thickness listed 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^2.^{o}F]; and k=upper value of the conductivity range listed in this table for applicable fluid temperature.

[2]These thicknesses are based on energy efficiency considerations only. Additional insulation is sometimes required relative to safety issues/surface temperatures.

503.2.9 HVAC system completion. Prior to the issuance of a certificate of occupancy, the design professional shall provide evidence of system completion in accordance with Sections 503.2.9.1 through 503.2.9.3.

503.2.9.1 Air distribution system testing, adjusting and balancing. Construction documents shall require that a written balance report be provided to the owner or the designated representative of the building owner for HVAC systems serving zones with a total conditioned area exceeding 5000 square feet (465 m^2). Air distribution systems shall be tested, adjusted, and balanced by an engineer licensed in this state or a company or individual holding a current certification from a recognized testing and balancing agency organization in accordance with generally accepted engineering standards.

Exceptions:

1. Buildings with cooling or heating system capacities of 15 tons or less per system may be tested and balanced by a mechanical contractor licensed to design and install such system(s).
2. Buildings with cooling or heating system capacities of 65,000 Btu/h or less per system are exempt from the requirements of this section.

Air system balancing shall be accomplished in a manner to first minimize throttling losses. Then for fans with fan system power greater than 1 hp, fan speeds shall be adjusted to meet design flow conditions. Balancing procedures shall be in accordance with the National Environmental Balancing Bureau (NEBB) Procedural Standards, the Associated Air Balance Council (AABC) National Standards, or equivalent procedures.

Exception: Damper throttling may be used for air system balancing with fan motors of 1 hp or less, or if throttling results in no greater than 1/3 hp fan horsepower draw above that required if the fan speed were adjusted.

NOTES:

1. Building envelope pressurization should be either neutral or positive to prevent infiltration of excess latent load.
2. Commercial kitchen hood exhaust cfm should be sized to prevent depressurization.

~~Each supply air outlet and *zone* terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *International Mechanical Code*.~~ Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 horsepower (hp) (7.4 kW) and larger.

503.2.9.2 Hydronic system balancing. Individual hydronic heating and cooling coils shall be equipped with means for balancing and pressure test connections.

503.2.9.3 Manuals. The construction documents shall require that an operating and maintenance manual be provided to the building owner by the mechanical contractor. The manual shall include, at least, the following:

1. Equipment capacity (input and output) and required maintenance actions.
2. Equipment operation and maintenance manuals.
3. HVAC system control maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field-determined setpoints shall be permanently recorded on control drawings, at control devices or, for digital control systems, in programming comments.
4. A complete written narrative of how each system is intended to operate.

503.2.10 Air system design and control. Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 horsepower (hp) shall meet the provisions of Sections 503.2.10.1 through 503.2.10.2

503.2.10.1 Allowable fan floor horsepower. Each HVAC system at fan system design conditions shall not exceed the allowable fan system motor nameplate hp (Option 1) or fan system bhp (Option 2) as shown in Table 503.2.10.1(1). This includes supply fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability.

Exceptions:

1. Hospital and laboratory systems that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.
2. Individual exhaust fans with motor nameplate horsepower of 1 hp or less.
3. Fans exhausting air from fume hoods. (Note: If this exception is taken, no related exhaust side credits shall be taken from Table 503.2.10.1(2) and the Fume Exhaust Exception Deduction must be taken from Table 503.2.10.1(2).

503.2.10.2 Motor nameplate horsepower. For each fan, the selected fan motor shall be no larger than the first available motor size greater than the brake horsepower (bhp). The fan brake horsepower (bhp) shall be indicated on the design documents to allow for compliance verification by the *code official*.

Exceptions:

1. For fans less than 6 bhp, where the first available motor larger than the brake horsepower has a nameplate rating within 50 percent of the bhp, selection of the next larger nameplate motor size is allowed.
2. For fans 6 bhp and larger, where the first available motor larger than the bhp has a nameplate rating within 30 percent of the bhp, selection of the next larger nameplate motor size is allowed

Table 503.2.10.1(1)
FAN POWER LIMITATION[1]

	Limit	Constant Volume	Variable Volume
Option 1: Fan System Motor Nameplate hp	Allowable nameplate motor hp	$Hp \leq CFM_S \times 0.0011$	$Hp \leq CFM_{Ss} \times 0.0015$
Option 2: Fan System bhp	Allowable fan system bhp	$Bhp \leq CFM_S \times 0.00094 + A$	$Bhp \leq CFM_{Ss} \times 0.0013 + A$

[1] Where:

CFM_S = the maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.

Hp = the maximum combined motor nameplate horsepower

Bhp = the maximum combined fan brake horsepower

A = sum of ($PD \times CFM_d/4131$)

Where:

PD = each applicable pressure drop adjustment from Table 503.2.10.1(1) in in. w.c.

CFM_D = the design airflow through each applicable device from Table 503,2,10.1(2) in cubic feet per minute.

Table 503.2.10.1(2)
FAN POWER LIMITATION

Device	Adjustment
Credits:	
Fully ducted return and/or exhaust air systems	0.5” w.c. 0.5 in. w.c.

Return and/or exhaust airflow control devices	The pressure drop of device calculated at fan system design condition
Exhaust filters, scrubbers, or other exhaust treatment	0.5 in. w.c.
Particulate filtration credit: MERV 9 through 12	0.9 in.. w.c.
Particulate filtration credit: Merv 13 through 15	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Pressure drop of device at fan system design condition
Heat recovery device	Pressure drop of device at fan system design condition
Evaporative humidifiers/cooler in series with another cooling coil	0.15 in. w.c.
Sound attenuation section	-1.0 in. w.c.
Deductions	
Fume Hood Exhaust Exception (required if 503.2.10.1, Exception 3 is taken)	

503.2.10.3 [13-407.AB.2.5.2] Optimum Start Controls. Individual heating and cooling air distribution systems with a total design supply air capacity exceeding 10,000 cfm (5 m^3/S), served by one or more supply fans, shall have optimum start controls. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint and the amount of time prior to scheduled occupancy.

503.2.10.4 [13-407.AB.2.5.3] Zone Isolation. HVAC systems serving zones that are intended to operate or be occupied non-simultaneously shall be divided into isolation areas. Zones may be grouped into a single isolation area provided it does not exceed 25,000 square feet (2 323 m^3) of conditioned floor area nor include more than one floor. Each isolation area shall be equipped with isolation devices capable of automatically shutting off the supply of conditioned air and outside air to and exhaust air from the area. Each isolation area shall be controlled independently by a device meeting the requirements of Section 503.2.4.3.2 (Automatic Shutdown). For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions: Isolation devices and controls are not required for the following:

1. Exhaust air and outside air connections to isolation zones when the fan system to which they connect is 5000 cfm and smaller.
2. Exhaust airflow from a single isolation zone of less than 10% of the design airflow of the exhaust system to which it connects.
3. Zones intended to operate continuously or intended to be inoperative only when all other zones are inoperative.

503.2.11 Heating outside a building. Systems installed to provide heat outside a building shall be radiant systems. Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically de-energized when no occupants are present.

503.2.12 Heating systems having additional functions. Space heating equipment used to provide additional functions (e.g. service water heating) as part of a combination (integrated) system shall comply with minimum performance requirements for the appropriate space heating equipment category. Service water heating equipment used to provide additional functions (e.g. space heating) as part of a combination (integrated) system shall, as a minimum, meet the minimum performance requirements for water heating equipment in Section 504.2.

503.3 Simple HVAC systems and equipment (Prescriptive).

This section applies to buildings served by unitary or packaged HVAC equipment listed in Tables 503.2.3(1) through 503.2.3(5), each serving one zone and controlled by a single thermostat in the zone served. ~~It also applies to two-pipe heating systems serving one or more zones, where no cooling system is installed.~~

This section does not apply to fan systems serving multiple zones, nonunitary or nonpackaged HVAC equipment and systems or hydronic or steam heating and hydronic cooling equipment and distribution systems that provide cooling or cooling and heating which are covered by Section 503.4.

503.3.1 Economizers. Reserved. ~~Supply air economizers shall be provided on each cooling system as shown in Table 503.3.1(1). Economizers shall be capable of providing 100 percent outdoor air, even if additional mechanical cooling is required to meet the cooling load of the building. Systems shall provide a means to relieve excess outdoor air during economizer operation to prevent overpressurizing the building. The relief air outlet shall be located to avoid recirculation into the building. Where a single room or space is supplied by multiple air systems, the aggregate capacity of those systems shall be used in applying this requirement.~~

~~**Exceptions:**~~

~~1. Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(1) or 503.2.3(2) and meets or exceeds the minimum cooling efficiency requirement (EER) by the percentages shown in Table 503.3.1(2).~~

~~2. Systems with air or evaporatively cooled condensors and which serve spaces with open case refrigeration or that require filtration equipment in order to meet the minimum ventilation requirements of Chapter 4 of the *International MechanicalCode*.~~

TABLE 505.3.1(1)
ECONOMIZER REQUIREMENTS Reserved.

Climate Zones	Economizer Requirement
1A, 1B, 2A, 7, 8	No requirement
2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B	Economizers on all cooling systems ≥54,000 Btu/h[a]

[a]The total capacity of all systems without economizers shall not exceed 480,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater.

503.3.2 Hydronic system controls. Hydronic systems of at least 300,000 Btu/h (87,930 W) design output capacity supplying heated and chilled water to comfort conditioning systems shall include controls that meet the requirements of Section 503.4.3.

503.4 Complex HVAC systems and equipment. (Prescriptive). This section applies to buildings served by HVAC equipment and systems not covered in Section 503.3.

503.4.1 Economizers. Reserved. ~~Supply air economizers shall be provided on each cooling system according to Table 503.3.1(1). Economizers shall be capable of operating at 100 percent outside air, even if additional mechanical cooling is required to meet the cooling load of the building.~~

~~**Exceptions:**~~

~~1. Systems utilizing water economizers that are capable of cooling supply air by direct or indirect evaporation or both and providing 100 percent of the expected system cooling load at outside air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and below.~~

~~2. Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(1), 503.2.3(2), or 503.2.3(6) and meets or exceeds the minimum EER by the percentages shown in Table 503.3.1(2)~~

~~3. Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(7) and meets or exceeds the minimum integrated part load value (IPLV) by the percentages shown in Table 503.3.1(2).~~

503.4.2Variable air volume (VAV) fan control.

503.4.2.1 Part-load fan power limitation. Individual VAV fans with motors of 10 horsepower (7.5 kW) or greater shall be either:

1. Driven by a mechanical or electrical variable speed drive; or
2. The fan shall be a vane-axial fan with variable-pitch blades; or.

3~~2~~. The fan motor shall have controls or devices that will result in fan motor demand of no more than 30 percent of their design wattage at 50 percent of design airflow when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.

503.4.2.2 Static pressure sensor location. Static pressure sensors used to control variable air volume fans shall be placed in a position such that the controller set point is no greater than one-third the total design fan static pressure, except for systems with zone reset control complying with Section 503.4.2.3. If this results in the sensor being located downstream of major duct splits, multiple sensors shall be installed in each major branch to ensure that static pressure can be maintained in each.

503.4.2.3 Set point reset. For systems with direct digital control of individual *zone* boxes reporting to the central control panel, the static pressure set point shall be reset based on the *zone* requiring the most pressure, i.e., the set point is reset lower until one *zone* damper is nearly wide open.

503.4.3 Hydronic systems controls. The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections 503.4.3.1 through 503.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include automatic controls capable of sequencing operation of the boilers. Hydronic heating systems comprised of a single boiler and greater than 500,000 Btu/h input design capacity shall include either a multistaged or modulating burner

503.4.3.1 Three-pipe system. Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

503.4.3.2 Two-pipe changeover system. Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a dead band between changeover from one mode to the other of at least 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for at least 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F (16.7°C) apart.

503.4.3.3 Hydronic (water loop) heat pump systems. Hydronic heat pump systems shall comply with Sections 503.4.3.3.1 through 503.4.3.3.3.

503.4.3.3.1 Temperature dead band. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature dead band of at least 20°F (11.1°C) between initiation of heat rejection and heat addition by the central devices.

Exception: Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on realtime conditions of demand and capacity, dead bands of less than 20°F (11°C) shall be permitted.

503.4.3.3.2 Heat rejection. Reserved. ~~Heat rejection equipment shall comply with Sections 503.4.3.3.2.1 and 503.4.3.3.2.2.~~

~~**Exception:** Where it can be demonstrated that a heat pump system will be required to reject heat throughout the year.~~

~~**503.4.3.3.2.1 Climate Zones 3 and 4.**~~

~~**503.4.3.3.2.2 Climate Zones 5 through 8.**~~

503.4.3.3.3 Two position valve. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 horsepower (hp) (7.5 kW) shall have a two-position valve.

503.4.3.4 Part load controls. Hydronic systems greater than or equal to 300,000 Btu/h (87 930 W) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that have the capability to:

1. Automatically reset the supply-water temperatures using zone-return water temperature, building-return water temperature, or outside air temperature as an indicator of building heating or cooling demand. The temperature shall be capable of being reset by at least 25 percent of the design supply-to-return water temperature difference; or
2. Reduce system pump flow by at least 50 percent of design flow rate utilizing adjustable speed drive(s) on pump(s), or multiple-staged pumps where at least one-half of the total pump horsepower is capable of being automatically turned off or control valves designed to modulate or step down, and close, as a function of load, or other *approved* means.

503.4.3.5 Pump isolation. Chilled water plants including more than one chiller shall have the capability to reduce flow automatically through the chiller plant when a chiller is shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

Boiler plants including more than one boiler shall have the capability to reduce flow automatically through the boiler plant when a boiler is shut down.

503.4.4 Heat rejection equipment fan speed control. Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

Exception: Factory-installed heat rejection devices within HVAC equipment tested and rated in accordance with Tables 503.2.3(6) and 503.2.3(7).

503.4.5 Requirements for complex mechanical systems serving multiple zones. Sections 503.4.5.1 through 503.4.5.5~~3~~ shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be VAV systems which, during periods of occupancy, are designed and capable of being controlled to reduce primary air supply to each *zone* to one of the following before reheating, recooling or mixing takes place:

1. Thirty percent of the maximum supply air to each *zone*.
2. Three hundred cfm (142 L/s) or less where the maximum flow rate is less than 10 percent of the total fan system supply airflow rate.
3. The minimum ventilation requirements of Chapter 4 of the *Florida Building Code*, ~~*International Mechanical Code*~~.

Exception: The following define when individual zones or when entire air distribution systems are exempted from the requirement for VAV control:

1. Zones where special pressurization relationships or cross-contamination requirements are such that VAV systems are impractical.
2. Zones or supply air systems where at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. Zones where special humidity levels are required to satisfy process needs.
4. Zones with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.
5. Zones where the volume of air to be reheated, recooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the *Florida Building Code*, ~~*International Mechanical Code*~~.
6. Zones or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the *zone*(s) and which are capable of preventing reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.
7. Systems that are designed and dedicated to condition only the outdoor ventilation air stream to meet the requirements of ASHRAE Standard 62. Such systems shall be controlled so that they do not allow overcooling of the building. Any building utilizing this exception that has a system that requires reheat, other than reclaimed waste heat, shall comply by Section 506 of this code.

503.4.5.1 Single duct variable air volume (VAV) systems, terminal devices. Single duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place.

503.4.5.2 Dual duct and mixing VAV systems, terminal devices. Systems that have one warm air duct and one cool air duct shall use terminal devices which are capable of reducing the flow from one duct to a minimum before mixing of air from the other duct takes place.

503.4.5.3 Single fan dual duct and mixing VAV systems, economizers. Individual dual duct or mixing heating and cooling systems with a single fan and with total capacities greater than 90,000 Btu/h [(26 375 W) 7.5 tons] shall not be equipped with air economizers.

503.4.5.4 Supply-air temperature reset controls. Multiple *zone* HVAC systems shall include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air

temperature. The controls shall be capable of resetting the supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Exceptions:

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
2. Seventy five percent of the energy for reheating is from site-recovered or site solar energy sources.
3. Zones with peak supply air quantities of 300 cfm (142 L/s) or less.

503.4.5.5 Dehumidification. Where humidistatic controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream.

Exceptions:

1. The system is capable of reducing supply air volume to 50 percent or less of the design airflow rate or the minimum rate specified in Section 6.1.3 of ASHRAE Standard 62, whichever is larger, before simultaneous heating and cooling takes place.
2. The individual fan cooling unit has a design cooling capacity of 80,000 Btu/h (23 448 W) or less and is capable of unloading to 50 percent capacity before simultaneous heating and cooling takes place
3. The individual mechanical cooling unit has a design cooling capacity of 40,000 Btu/h (11 724 W) or less. An individual mechanical cooling unit is a single system composed of a fan or fans and a cooling coil capable of providing mechanical cooling.
4. Systems serving spaces where specific humidity levels are required to satisfy process needs, such as computer rooms, museums, surgical suites, and buildings with refrigerating systems, such as supermarkets, refrigerated warehouses, and ice arenas. This exception also applies to other applications for which fan volume controls in accordance with Exception 1 are proven to be impractical to the enforcement agency.
5. At least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered (including condenser heat) or site solar energy source.
6. Systems where the heat added to the airstream is the return air enthalpy result of the use of a desiccant system and 75 percent of the heat added by the desiccant system is removed by a heat exchanger, either before or after the desiccant system with energy recovery.

503.4.6 Heat recovery for service water heating. Condenser heat recovery shall be installed for heating or reheating of service hot water provided the facility operates 24 hours a day, the total installed heat capacity of water-cooled systems exceeds 6,000,000 Btu/hr of heat rejection, and the design service water heating load exceeds 1,000,000 Btu/h.

The required heat recovery system shall have the capacity to provide the smaller of:

1. Sixty percent of the peak heat rejection load at design conditions; or
2. The preheating required to raise the peak service hot water draw to 85°F (29°C).

Exceptions:

1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.
2. Facilities that provide 60 percent of their service water heating from site solar or site recovered energy or from other sources.

503.4.7 [ASHRAE 6.5.9] [13-407.AB.2.2] 50~~2.4.4~~ Hot Gas Bypass Limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited to the following:.

Rated Capacity	**Max. Hot Gas Bypass Capacity (% Total Capacity)**
≤ 240,000 Btu/h	50 percent
> 240,000 Btu/h	25 percent

Exception: Unitary packaged systems with cooling capacities not greater than 90,000 Btu/h (432 W).

503.4.8 [13-407.AB.3.3] Condensing coils installed in cool air stream of another air-conditioning unit. The condensing coil of one air-conditioning unit shall not be installed in the cool air stream of another air-conditioning unit.

Exceptions:

1. Where condenser heat reclaim is used in a properly designed system including enthalpy control devices to achieve requisite humidity control for process, special storage or equipment spaces and occupant comfort within

the criteria of Standard ASHRAE Standard 55. Such systems shall result in less energy use than other appropriate options.
2. For computer or clean rooms whose location precludes the use of systems which would not reject heat into conditioned spaces.

SECTION 504
SERVICE WATER HEATING
(Mandatory)

504.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

504.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table 504.2. The efficiency shall be verified through data furnished by the manufacturer or through certification under an *approved* certification program.

503.4.3.6 Combination water and space heating systems. Combination water and space heating systems with input ratings of less than 105,000 Btu/h shall utilize a water heater listed by the Gas Appliance Manufacturer's Association (GAMA). Changeouts of burners to increase capacity shall not be made unless the unit has been listed at that capacity by GAMA.

504.3 Temperature controls. Service water-heating equipment shall be provided with controls to allow a setpoint of 110°F (43°C) for equipment serving dwelling units and 90°F (32°C) for equipment serving other occupancies. The outlet temperature of lavatories in public facility rest rooms shall be limited to 110°F (43°C).

504.4 Heat traps. Water-heating equipment not supplied with integral heat traps and serving noncirculating systems shall be provided with heat traps on the supply and discharge piping associated with the equipment.

504.5 Pipe insulation. For automatic-circulating hot water systems, piping shall be insulated with 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h _ ft^2 _ °F (1.53 W per 25 mm/m^2 _ K). The first 8 feet (2438 mm) of piping in noncirculating systems served by equipment without integral heat traps shall be insulated with 0.5 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h _ ft^2 _ °F (1.53 W per 25 mm/m^2 _ K).

504.6 Hot water system controls. Automatic-circulating hot water system pumps or heat trace shall be arranged to be conveniently turned off automatically or manually when the hot water system is not in operation.

TABLE 504.2
Minimum Performance of Water-Heating Equipment

Equipment Type	Size Category (input)	Subcategory or Rating Condition	Performance Required[1,2]	Test Procedure
Water heaters, Electric	≤ 12kW	Resistance	0.97-0.00132V, EF	DOE 10 CRF Part 430[3]
	>12 kW	Resistance	1.73V + 155 SL, Btu/h	ANSI Z21.10.3
	≤24 Amps & ≤ 250Volts	Heat Pump	0.93-0.00132V, EF	DOE 10 CFR Part 430[3]
Storage water heaters, Gas	≤ 75,000 Btu/h	≥ 20 gal	0.67-0.0019V, EF	DOE 10 CFR Part 430[3]
	75,000 Btu/h and ≤ 155,000 Btu/h	<4,000 (Btu/h)/gal	80% E_t (Q/800+110$\sqrt{}$V) SL, Btu/h	ANSI Z21.10.3
	>155,000 Btu/h	<4,000 (Btu/h)/gal	80% E_t (Q/800+110$\sqrt{}$V) SL, Btu/h	

Instantaneous water heaters, gas	>50,000 Btu/h and <200,000 Btu/h[4]	≥4,000 (Btu/h)/gal and < 2 gal	0.62-0.0019V, EF	DOE 10 CFR Part 430
	≥200,000 Btu/h	≥4,000 (Btu/h)/gal and <10 gal	80% E_t	ANSI Z21.10.3
	≥200,000 Btu/h	>4,000 (Btu/h)/gal and ≥10 gal	80% E_t (Q/800+110√V) SL, Btu/h	
Storage water heaters, Oil	≤ 105,000 Btu/h	≥ 20 gal	0.59-0.0019V, EF	DOE 10 CFR Part 430[3]
	>105,000 Btu/h	< 4,000 (Btu/h)/gal	78% E_t (Q/800+100√V) SL, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, Oil	≤ 210,000 Btu/h	≥4,000 (Btu/h)/gal and <2 gal	0.59-0.0019V, EF	DOE 10 CFR Part 430
	>210,000 Btu/h	≥4,000 (Btu/h)/gal and <10 gal	80% E_t	ANSI Z21.10.3
	>210,000 Btu/h	≥4,000 (Btu/h)/gal and ≥10 gal	78% E_t (Q/800+110√V) SL, Btu/h	
Hot water supply boilers, Gas and Oil	≥300,000 Btu/h and <12,500,000 Btu/h	≥4,000 (Btu/h)/gal and <10 gal	80% E_t	ANSI Z21.10.3
Hot water supply boilers, Gas	≥300,000 Btu/h and <12,500,000 Btu/h	≥4000 (Btu/h)/gal and ≥10 Gal	80% E_t (Q/800+110√V) SL, Btu/h	
Hot Water Supply Boilers, Oil	≥300,000 Btu/h and <12,500,000 Btu/h	>4000 (Btu/h)/gal and >10 Gal	78% E_t (Q/800+110√V) SL, Btu/h	
Pool heaters, Gas and Oil	All	--	78% E_t	ASHRAE 146
Heat pump pool heaters	All	---	4.0 COP At low air temperature	AHRI 1160[d]
Unfired storage tanks	All		Minimum insulation requirement R-12.5 (h.ft2.°F)/Btu	(none)

For SI: 1 Btu/h=.2931W, °C=[(°F) – 32]/1.8

a Energy factor (ER) and thermal efficiency (E_t) are minimum requirements. In the EF equation, V is the rated volume in gallons.

b. Standby loss (SL) is maximum Btu/h based on a 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h.

In the SL equation for electric water heaters, V is the rated volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons.

c Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

d Test reports from independent laboratories are required to verify procedure compliance.

504.7 Pools. Pools shall be provided with energy conserving measures in accordance with Sections 504.7.1 through 504.7.~~4~~3.

504.7.1 Pool heaters. All pool heaters shall meet the minimum efficiency listed for that type of pool heater in Table 504.2 and shall be equipped with a readily *accessible* on-off switch that is mounted outside the heater to allow shutting off the heater without adjusting the thermostat setting. Pool heaters fired by natural gas or LPG shall not have continuously burning pilot lights.

504.7.2 Time switches. 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.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Where pumps are required to operate solar-and waste-heat-recovery pool heating systems.

504.7.3 Pool covers. Heated pools shall be equipped with a vapor retardant pool cover on or at the water surface. Pools heated to more than 90°F (32°C) shall have a pool cover with a minimum insulation value of R-12.

Exception: Pools deriving over 60 percent of the energy for heating from site-recovered energy or solar energy source.

504.7.4 Pool pump motors. Pool pump motors shall not be split-phase, shaded-pole or capacitor start-induction run types.

SECTION 505
ELECTRICAL POWER AND LIGHTING SYSTEMS

(Mandatory)

505.1 General (Mandatory). This section covers lighting system controls, the connection of ballasts, the maximum lighting power for interior applications and minimum acceptable lighting equipment for exterior applications including facades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies; and exterior building grounds lighting provided through the building's electrical service.

Exceptions:

1. Lighting within dwelling units where 50 percent or more of the permanently installed interior light fixtures are fitted with high-efficacy lamps

2. Emergency lighting that is automatically off during normal building operation,

3. Lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation,

4. Decorative gas lighting systems.

505.2 Lighting controls (Mandatory). Lighting systems shall be provided with controls as required in Sections 505.2.1, 505.2.2, 505.2.3 and 505.2.4.

505.2.1 Interior lighting controls. Each area enclosed by walls or floor-to-ceiling partitions shall have at least one control device to independently control the general lighting within the space. Each manual device shall be readily accessible and located so the occupants can see the controlled lighting.

Exception: Remote location shall be permitted for reasons of safety or security when the remote control device has an indicator pilot light as part of or next to the control device and the light is clearly labeled to identify the controlled lighting. ~~manual control for the lighting serving that area. The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights served and indicates their status.~~

~~**Exceptions:**~~

~~1. Areas designated as security or emergency areas that must be continuously lighted.~~

~~2. Lighting in stairways or corridors that are elements of the means of egress~~

505.2.1.1 Classrooms and meeting rooms. A control device shall be installed in classrooms (except shop classrooms, laboratory classrooms, and preschool through 12th grade classrooms), conference/meeting rooms and employee lunch and break rooms that automatically turns lighting off within 30 minutes of all occupants leaving a space. These spaces are not required to be connected to other automatic lighting shutoff controls.

Exception: Spaces with multi-scene control, **[Add to definitions:** "Multi-scene control. A lighting control device or system that allows for two or more pre-defined lighting settings, in addition to all off, for two or more groups of luminaires to suit multiple activities in the space, and allows the automatic recall of those settings."**]**

505.2.1.2 All other spaces. Each control device shall be activated either manually by an occupant or automatically by sensing an occupant and be capable of overriding any time-of-day scheduled shut-off control for no more than four hours in accordance with Section 505.2.2.1. Spatial control shall be limited as follows:

Space size	Maximum controlled space
≤ 10,000 square feet (929 m^2)	2,500 square feet (232 m^2)
> 10,000 square feet (929 m^2)	10,000 square feet (929 m^2)

505.2.1.3 Additional Controls. Additional controls are required in the following cases:

1..Display or Accent Lighting. Display or accent lighting shall have a separate control.

2. Case Lighting. Lighting in cases used for display purposes shall have a separate control device.

3 ~~505.2.3~~ **Sleeping unit controls.** *Sleeping unit*s in hotels, motels, boarding houses or similar buildings shall have at least one master switch at the main entry door that controls all permanently wired luminaires and switched receptacles, except those in the bathroom(s) [Not a FL exception]. Suites shall have a control meeting these requirements at the entry to each room or at the primary entry to the suite.

~~4~~. Task Lighting. Supplemental task lighting, including permanently installed undershelf or undercabinet lighting, shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device is readily accessible and located so that the occupant can see the controlled lighting.

5. Non-visual Lighting. Lighting for nonvisual applications, such as plant growth and food warming, shall have a separate control device.

6. Demonstration Lighting. Lighting equipment that is for sale or for demonstrations in lighting education shall have a separate control device.

~~**505.2.2 Additional controls.** Each area that is required to have a manual control shall have additional controls that meet the requirements of Sections 505.2.2.1 and 505.2.2.2.~~

~~**505.2.2.1 Light reduction controls.** Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent.~~

~~Lighting reduction shall be achieved by one of the following or other *approved* method:~~

~~1. Controlling all lamps or luminaires;~~

~~2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps;~~

~~3. Switching the middle lamp luminaires independently of the outer lamps; or~~

~~4. Switching each luminaire or each lamp.~~

~~**Exceptions:**~~

~~1. Areas that have only one luminaire.~~

~~2. Areas that are controlled by an occupant sensing device.~~

~~3. Corridors, storerooms, restrooms or public lobbies.~~

~~4. *Sleeping unit* (see Section 505.2.3).~~

~~5. Spaces that use less than 0.6 watts per square foot (6.5 W/m^2).~~

505.2.2.~~2~~ Automatic lighting shutoff. Buildings larger than 5,000 square feet (465m^2) shall be equipped with an automatic control device to shut off lighting in those areas. This automatic control device shall function on either:

1. A scheduled basis, using time-of-day, with an independent program schedule that controls the interior lighting in areas that do not exceed 25,000 square feet (2323 m^2) and are not more than one floor; or
2. An occupant sensor that shall turn lighting off within 30 minutes of an occupant leaving a space; or
3. A signal from another control or alarm system that indicates the area is unoccupied

Exception: The following shall not require an automatic control device:

1. *Sleeping unit* (see Section 505.2.1.3).
2. Lighting intended for 24-hour operation.
3. Lighting in spaces where patient care is directly provided
4. Spaces where an automatic shutoff would endanger occupant safety or security.

505.2.2.~~2~~.1 Occupant override. Where an automatic time switch control device is installed to comply with Section 505.2.2.~~2~~, Item 1, it shall incorporate an override switching device that:

1. Is readily *accessible*.
2. Is located so that a person using the device can see the lights or the area controlled by that switch, or so that the area being lit is annunciated.
3. Is manually operated by an occupant or automatically by sensing an occupant.
4. Meets the requirements of Section 505.2.1.2 ~~Allows the lighting to remain on for no more than 2 [FL is 4 hours] hours when an override is initiated.~~
5. ~~Controls an area not exceeding 5,000 square feet (465 m^2)~~.

~~**Exceptions:**~~

~~1. In malls and arcades, auditoriums, single tenant retail spaces, industrial facilities and arenas, where captive key override is utilized, override time shall be permitted to exceed 2 hours.~~

~~2. In malls and arcades, auditoriums, single tenant retail spaces, industrial facilities and arenas, the area controlled shall not exceed 20,000 square feet (1860 m^2).~~

505.2.2.2.~~2~~ Holiday scheduling. If an automatic time switch control device is installed in accordance with Section 505.2.2.~~2~~, Item 1, it shall incorporate an automatic holiday scheduling feature that turns off all loads for at least 24 hours, then resumes the normally scheduled operation.

Exception: Retail stores and associated malls, restaurants, grocery stores, places of religious worship and theaters.

505.2.~~2~~.3 Daylight zone control. Daylight zones, as defined by this code, shall be provided with individual controls that control the lights independent of general area lighting. Contiguous daylight zones adjacent to vertical fenestration are allowed to be controlled by a single controlling device provided that they do not include zones facing more than two adjacent cardinal orientations (i.e., north, east, south, west). Daylight zones under skylights more than 15 feet (4572 mm) from the perimeter shall be controlled separately from daylight zones adjacent to vertical fenestration. [Not in FL]

Exception: Daylight spaces enclosed by walls or ceiling height partitions and containing two or fewer light fixtures are not required to have a separate switch for general area lighting.

~~**505.2.3 Sleeping unit controls.** *Sleeping units* in hotels, motels, boarding houses or similar buildings shall have at least one master switch at the main entry door that controls all permanently wired luminaires and switched receptacles, except those in the bathroom(s). Suites shall have a control meeting these requirements at the entry to each room or at the primary entry to the suite.~~

505.2.4 Exterior lighting controls. Lighting for all exterior applications not exempted in Section 505.1 shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours. Lighting not designated for dusk-to-dawn operation shall be controlled by either a combination of a photosensor and a time switch, or an astronomical time switch.

Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. All time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least 10 hours.

Exception: Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaptation.

505.3 Tandem wiring (Mandatory). Luminaires designed for use with one or three linear fluorescent lamps >30 W each ~~The following luminaires located within the same area~~ shall be tandem wired when two or more luminaires are in the same space and on the same control device.

Exceptions:

1. Recessed luminaires more than 10 feet (3048 mm) apart measured center to center.
2. Surface-mounted or pendant luminaires that are not continuous.
3. Luminaires using three-lamp high-frequency electronic or three-lamp electromagnetic ballasts.
4. Recessed luminaires more than 10 feet (3048 mm) apart measured center to center.
5. Surface-mounted or pendant luminaires that are not continuous.
6. Luminaires using three-lamp high-frequency electronic or three-lamp electromagnetic ballasts.

~~1. Fluorescent luminaires equipped with one, three or odd-numbered lamp configurations, that are recessmounted within 10 feet (3048 mm) center-to-center of each other.~~

~~2. Fluorescent luminaires equipped with one, three or any odd-numbered lamp configuration, that are pendant- or surface-mounted within 1 foot (305 mm) edge-to-edge of each other.~~

~~**Exceptions:**~~

~~1. Where electronic high-frequency ballasts are used.~~

~~2. Luminaires on emergency circuits.~~

~~3. Luminaires with no available pair in the same area.~~

505.4 Exit signs (Mandatory). Internally illuminated exit signs shall not exceed 5 watts per side. [Same]

505.5 Interior lighting power requirements (Prescriptive). A building complies with this section if its total connected lighting power calculated under Section 505.5.1 is no greater than the interior lighting power calculated under Section 505.5.2.

505.5.1 Total connected interior lighting power. The total connected interior lighting power (watts) shall be the sum of the watts of all interior lighting equipment as determined in accordance with Sections 505.5.1.1 through 505.5.1.4.

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
   1.1. Professional sports arena playing field lighting.
   1.2. *Sleeping unit* lighting in hotels, motels, boarding houses or similar buildings.
   1.3. Emergency lighting automatically off during normal building operation.
   1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs including the visually impaired visual impairment and other medical and age-related issues.
   1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.
   1.6. Casino gaming areas.
2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:
   2.1. Task lighting for medical and dental purposes.
   2.2. Display lighting for exhibits in galleries, museums and monuments.
3. Lighting for theatrical purposes, including performance, stage, film production and video production.
4. Lighting for photographic processes.
5. Lighting integral to equipment or instrumentation and is installed by the manufacturer.
6. Task lighting for plant growth or maintenance.
7. Advertising signage or directional signage.
8. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.
9. Lighting equipment that is for sale.
10. Lighting demonstration equipment in lighting education facilities.
11. Lighting *approved* because of safety or emergency considerations, inclusive of exit lights.
12. Lighting integral to both open and glass enclosed refrigerator and freezer cases.
13. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
14. Furniture mounted supplemental task lighting that is controlled by automatic shutoff.

505.5.1.1 Screw lamp holders. The wattage shall be the maximum *labeled* wattage of the luminaire.

505.5.1.2 Low-voltage lighting. The wattage shall be the specified wattage of the transformer supplying the system.

505.5.1.3 Other luminaires. The wattage of all other lighting equipment shall be the wattage of the lighting equipment verified through data furnished by the manufacturer
or other *approved* sources.

505.5.1.4 Line-voltage lighting track and plug-in busway. The wattage shall be:
   1. The specified wattage of the luminaires included in the system with a minimum of 30 W/lin ft. (98 W/lin. m);
   2. The wattage limit of the system's circuit breaker; or
   3. The wattage limit of other permanent current limiting device(s) on the system.

505.5.2 Interior lighting power. The total interior lighting power (watts) is the sum of all interior lighting powers for all areas in the building covered in this permit. The interior lighting power is the floor area for each building area type listed in Table 505.5.2 times the value from Table 505.5.2 for that area. For the purposes of this method, an "area" shall be defined as all contiguous spaces that accommodate or are associated with a single building area type as *listed* in Table 505.5.2. When this method is used to calculate the total interior lighting power for an entire building, each building area type shall be treated as a separate area.

TABLE 505.5.2
Lighting Power Densities (LPD) Using the Space-By-Space Method

Common Space Types[1]	LPD (W/ft^2)	Building Specific Space Types (Cont.)	LPD (W/ft^2)
Office—enclosed	1.1	Fire stations	
Office--open plan	1.1	Fire station engine room	0.8
Conference/Meeting/Multipurpose	1.3	Sleeping quarters	0.3
Classroom/Lecture/Training	1.4	Post Office—sorting area	1.2
for Penitentiary	1.3	Convention center—exhibit space	1.3
Lobby	1.3	Library	
for Hotel	1.1	Card file & cataloguing	1.1

for Performing arts theater	3.3	Stacks	1.7
for motion picture theatre	1.1	Reading area	1.2
Audience/seating area	0.9	Hospital	
for Gymnasium	0.4	Emergency	2.7
for Exercise center	0.3	Recovery	0.8
for Convention center	0.7	Nurse station	1.0
for Penitentiary	0.7	Exam/Treatment	1.5
for Religious buildings	1.7	Pharmacy	1.2
for Sports arena	0.4	Patient room	0.7
for Performing arts theatre	2.6	Operating room	2.2
for Motion picture theatre	1.2	Nursery	0.6
for Transportation	0.5	Medical supply	1.4
Atrium—first three floors	0.6	Physical therapy	0.9
Atrium—each additional floor	0.2	Radiology	0.4
Lounge/Recreation	1.2	Laundry/Washing	0.6
for Hospital	0.8	Automotive—Service/Repair	0.7
Dining area	0.9	Manufacturing	
for Penitentiary	1.3	Low bay (<25 ft floor to ceiling height)	1.2
for Hotel	1.3	High bay (>25 ft floor to ceiling height)	1.7
for Motel	1.2	Detailed manufacturing	2.1
for Bar lounge/Leisure dining	1.4	Equipment room	1.2
for Family dining	2.1	Control room	0.5
Food preparation	1.2	Hotel/Motel guest rooms	1.1
Laboratory	1.4	Dormitory—Living quarters	1.1
Restrooms	0.9	Museum	
Dressing/Locker/Fitting room	0.6	General exhibition	1.0
Corridor/Transition	0.5	Restoration	1.7
for Hospital	1.0	Bank/Office—banking activity area	1.5
For Manufacturing facility	0.5	Religious buildings	
Stairs—active	0.6	Worship—pulpit, choir	2.4
Active storage	0.8	Fellowship hall	0.9
for Hospital	0.9	Retail (for accent lighting see Sec.415.B.2)	
Inactive storage	0.3	Sales area[2]	1.7
for Museum	0.8	Mall concourse	1.7
Electrical/mechanical	1.5	Sports arena	
Workshop	1.9	Ring sports area	2.7
		Court sports area	2.3
Building Specific Space types		Indoor playing field area	1.4
Gymnasium/Exercise center		Warehouse	
Playing area	1.4	Fine material storage	1.4
Exercise area	0.9	Medium/bulky material storage	0.9
Courthouse/Police station/ Penitentiary		Parking garage—garage area	0.2
Courtroom	1.9	Transportation	
Confinement cells	0.9	Airport—concourse	0.6
Judges chambers	1.3	Air/Train/Bus—Baggage area	1.0
		Terminal—Ticket counter	1.5

[1] In cases where both a common space type and a building specific space type are listed, the building specific space type shall apply.

505.6 Exterior lighting. (Mandatory). When the power for exterior lighting is supplied through the energy service to the building, all exterior lighting, other than low-voltage landscape lighting, shall comply with Sections 505.6.1 and 505.6.2.

Exception: Where *approved* because of historical, safety, signage or emergency considerations.

505.6.1 Exterior building grounds lighting. All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lumens per watt unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under Section 505.6.2.

505.6.2 Exterior building lighting power. The total exterior lighting power allowance for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are to be illuminated and are permitted in Table 505.6.2(2) for the applicable lighting *zone*. Tradeoffs are allowed only among exterior lighting applications listed in Table 505.6.2(2), Tradable Surfaces section. The lighting zone for the building exterior is determined from Table 505.6.2(1) unless otherwise specified by the local jurisdiction. Exterior lighting for all applications (except those included in the exceptions to Section 505.6.2) shall comply with the requirements of Section 505.6.1.

Exceptions: Lighting used for the following exterior applications is exempt when equipped with a control device independent of the control of the nonexempt lighting:

1. Specialized signal, directional and marker lighting associated with transportation;
2. Advertising signage or directional signage;
3. Integral to equipment or instrumentation and is installed by its manufacturer;
4. Theatrical purposes, including performance, stage, film production and video production;
5. Athletic playing areas;
6. Temporary lighting;
7. Industrial production, material handling, transportation sites and associated storage areas;
8. Theme elements in theme/amusement parks; and
9. Used to highlight features of public monuments and registered historic landmark structures or buildings.

TABLE 505.6.2(1)
EXTERIOR LIGHTING ZONES
LIGHTING ZONE

Lighting Zone	Description
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority.

TABLE 505.6.2(2)
LIGHTING POWER DENSITIES FOR BUILDING EXTERIORS

Applications	Lighting Power Densities
Tradable Surfaces (Lighting Power Densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded.)	
Uncovered Parking Areas	
Parking lots and drives	0.15 W/ft^2
Building Grounds	
Walkways less than 10 feet wide	1.0 watts per linear foot
Walkways 10 feet wide or greater, plaza areas, and special feature areas	0.2 W/ft^2
Stairways	1.0 W/ft^2
Building Entrances and Exits	
Main entries	30 watts per linear foot of door width
Other doors	20 watts per linear foot of door width
Canopies and Overhangs	
Canopies (freestanding and attached and overhangs)	1.25 W/ft^2
Outdoor Sales	
Open areas (including vehicle sales lots)	0.5 W/ft^2

Street frontage for vehicle sales lots in addition to "open area" allowance	20 watts per linear foot
Non-Tradable Surfaces (Lighting Power Density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	
Building facades	0.2 W/ft^2 for each illuminated wall or surface or 5.0 watts per linear foot for each illuminated wall or surface length
Automated teller machines and night depositories	270 watts per location plus 90 watts per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	1.25 W/ft^2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
Loading areas for law enforcement, fire, ambulance, and other emergency service vehicles	0.5 W/ft^2 of uncovered area (covered areas are included in the Canopies and Overhangs" section of "Tradable Surfaces")
Drive-up windows at fast food restaurants	400 watts per drive-through
Parking near 24-hour retail entrances	800 watts per main entry

505.7 Electrical power

505.7.1 Applicability. This section applies to all building power distribution systems. The provisions for electrical distribution for all sections of this Code are subject to the applicable Florida Public Service Commission rules regarding electric utilities set forth in Chapter 25-6, *Florida Administrative Code*, and the design conditions in *ASHRAE Standard 90.1*.

505.7.2 Electrical metering ~~energy consumption~~. (Mandatory). In buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

505.7.3 Voltage Drop

505.7.3.1 Feeders and customer owned service conductors. Feeder and customer owned service conductors shall be sized for a maximum voltage drop of 2 percent at design load.

505.7.3.2 Branch Circuits. Branch circuit conductors shall be sized for a maximum voltage drop of 3 percent at design load

505.7.4 Completion Requirements

505.7.4.1 Drawings. Construction documents shall require that within 30 days after the date of system acceptance, record drawings of the actual installation shall be provided to the building owner, including:

1. a single-line diagram of the building electrical distribution system and
2. floor plans indicating location and area served for all distribution.

505.7.4.2 Manuals. Construction documents shall require that an operating manual and maintenance manual be provided to the building owner. The manuals shall include, at a minimum, the following:

1. Submittal data stating *equipment* rating and selected options for each piece of *equipment* requiring maintenance.
2. Operation manuals and maintenance manuals for each piece of *equipment* requiring maintenance. Required routine maintenance actions shall be clearly identified.
3. Names and addresses of at least one qualified service agency.

Note: Enforcement agencies should only check to be sure that the construction documents require this information to be transmitted to the owner and should not expect copies of any of the materials.

505.7.5 Electric Motors. Electric motors shall comply with the requirements of the Energy Policy Act of 1992 where applicable, as shown in Table 505.7.4. Motors that are not included in the scope of the Energy Policy Act have no performance requirements in this section.

TABLE 505.7.5
MINIMUM NOMINAL EFFICIENCY FOR
GENERAL PURPOSE Design A and Design B Motors[1]

	Minimal Nominal Full-Load Efficiency (%)					
	Open Motors			Enclosed Motors		
Number of Poles	2	4	6	2	4	6
Synchronous speed (RPM)	3600	1800	1200	3600	1800	1200
Motor Horsepower						
1.0	----	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2.0	84.0	84.0	85.5	84.0	84.0	86.5
3.0	84.0	86.5	86.5	85.5	87.5	87.5
5.0	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10.0	88.5	89.5	90.2	89.5	89.5	89.5
15.0	89.5	91.0	90.2	90.2	91.0	90.2
20.0	90.2	91.0	91.0	90.2	91.0	90.2
25.0	91.0	91.7	91.7	91.0	92.4	91.7
30.0	91.0	92.4	92.4	91.0	92.4	91.7
40.0	91.7	93.0	93.0	91.7	93.0	93.0
50.0	92.4	93.0	93.0	92.4	93.0	93.0
60.0	93.0	93.6	93.6	93.0	93.6	93.6
75.0	93.0	94.1	93.6	93.0	94.1	93.6
100.0	93.0	94.1	94.1	93.6	94.5	94.1
125.0	93.6	94.5	94.1	94.5	94.5	94.1
150.0	93.6	95.0	94.5	94.5	95.0	95.0
200.0	94.5	95.0	94.5	95.0	95.0	95.0

[1] Nominal efficiencies shall be established in accordance with NEMA Standard MG1. Design A and Design B are National Electric Manufacturers Association (NEMA) design class designations for fixed frequency small and medium AC squirrel-cage induction motors.

SECTION 506
TOTAL BUILDING PERFORMANCE

506.1 Scope. This section establishes criteria for compliance using total building performance. The following systems and loads shall be included in determining the total building performance: heating systems, cooling systems, service water heating, fan systems, lighting power, receptacle loads and process loads.

506.2 Mandatory requirements. Compliance with this section requires that the criteria of Sections 502.4, 503.2, 504 and 505 be met.

TABLE 505.6.2
LIGHTING POWER DENSITIES FOR BUILDING EXTERIORS

TABLE 505.6.2(2)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

506.3 Performance-based compliance. Compliance based on total building performance requires that a proposed building (*proposed design*) be shown to have an annual energy cost that is less than or equal to the annual energy cost of the *standard reference design*. Energy prices shall be taken from a source *approved* by the Florida Building Commission ~~*code official*, such as the Department of Energy, Energy Information Administration's *State Energy Price and Expenditure Report*. *Code officials* shall be permitted to require time-of-use pricing in energy cost calculations.~~ Nondepletable energy collected off site shall be treated and priced the same as purchased energy. Energy from nondepletable energy sources collected on site shall be omitted from the annual energy cost of the *proposed design*.

~~**Exception:** Jurisdictions that require site energy (1 kWh = 3413 Btu) rather than energy cost as the metric of comparison.~~

506.4 Documentation. ~~Documentation verifying that the methods and accuracy of~~ The EnergyGauge Summit Fla/Com compliance software tools shall be utilized to conform to the provisions of this section ~~shall be provided to the *code official*~~.

506.4.1 Compliance report. The c~~C~~ompliance software tool~~s~~ shall generate a Form 506 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 be submitted to the building official before a building permit is issued and shall include the following information:

1. Address of the building;
2. An inspection checklist documenting the building component characteristics of the *proposed design* as *listed* in Table 506.5.1(1). The inspection checklist shall show the estimated annual energy cost for both the *standard reference design* and the *proposed design*;
3. Name of individual completing the compliance report; and
4. Name and version of the compliance software tool.

506.4.2 Additional documentation. The *code official* shall ~~be permitted to~~ require the following documents:

1~~. Documentation of the building component characteristics of the *standard reference design*;~~
2. Thermal zoning diagrams consisting of floor plans showing the thermal zoning scheme for the ~~*standard reference design* and~~ *proposed design*.
3. Input and output report(s) from the energy analysis simulation program containing the complete input and output files, as applicable. The output file shall include energy use totals and energy use by energy source and end-use served, total hours that space conditioning loads are not met and any errors or warning messages generated by the simulation tool as applicable;
4. An explanation of any error or warning messages appearing in the simulation tool output; and
5. A certification signed by the design professionals responsible under Florida law for the design of lighting, electrical, mechanical, and plumbing systems and the building shell ~~builder~~ providing the building component characteristics of the *proposed design* as given in Table 506.5.1(1). See Section 103.1 of this code.

506.5 Calculation procedure. Except as specified by this section, the *standard reference design* and *proposed design* shall be configured and analyzed using identical methods and techniques.

506.5.1 Building specifications. The *standard reference design* and *proposed design* shall be configured and analyzed as specified by Chapter 11 of the 2004 ASHRAE Standard 90.1. ~~Table 506.5.1(1). Table 506.5.1(1) shall include by reference all notes contained in Table 502.2(1).~~ The *Standard Reference Design* totals for the Total Building Performance compliance method ~~developed in accordance with the criteria in Table 506.5.1(1)~~ shall be adjusted by a factor of 0.80 to make the code 20 percent more stringent than the "2007" Florida energy code's *Standard Reference Design* (Baseline) features.

506.5.2 Thermal blocks. The *standard reference design* and *proposed design* shall be analyzed using identical thermal blocks as required in Section 506.5.1.1, 506.2.2 or 506.5.2.3

506.5.2.1 HVAC zones designed. Where HVAC zones are defined on HVAC design drawings, each HVAC *zone* shall be modeled as a separate thermal block.

Exception: Different HVAC zones shall be allowed to be combined to create a single thermal block or identical thermal blocks to which multipliers are applied provided:

1. The space use classification is the same throughout the thermal block.

2. All HVAC zones in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations are within 45 degrees (0.79 rad) of each other.

3. All of the zones are served by the same HVAC system or by the same kind of HVAC system.

506.5.2.2 HVAC zones not designed. Where HVAC zones have not yet been designed, thermal blocks shall be defined based on similar internal load densities, occupancy, lighting, thermal and temperature schedules, and in combination with the following guidelines:

1. Separate thermal blocks shall be assumed for interior and perimeter spaces. Interior spaces shall be those located more than 15 feet (4572 mm)from an exterior wall. Perimeter spaces shall be those located closer than 15 feet (4572 mm) from an *exterior wall*.

2. Separate thermal blocks shall be assumed for spaces adjacent to glazed exterior walls: a separate *zone* shall be provided for each orientation, except orientations that differ by no more than 45 degrees (0.79 rad) shall be permitted to be considered to be the same orientation. Each *zone* shall include floor area that is 15 feet (4572 mm) or less from a glazed perimeter wall, except that floor area within 15 feet (4572 mm) of glazed perimeter walls having more than one orientation shall be divided proportionately between zones

3. Separate thermal blocks shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.

4. Separate thermal blocks shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.

506.5.2.3 Multiple family residential buildings. Residential spaces shall be modeled using one thermal block per space except that those facing the same orientations are permitted to be combined into one thermal block. Corner units and units with roof or floor loads shall only be combined with units sharing these features

506.6 Calculation software tools. Calculation procedures used to comply with this section shall be those included in the EnergyGauge Summit Fla/Com software tools ~~capable of~~ in 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.

1. Computer generation of the *standard reference design* using only the input for the *proposed design*. The calculation procedure shall not allow the user to directly modify the building component characteristics of the *standard reference design*.

2. Building operation for a full calendar year (8760 hours).

3. Climate data for a full calendar year (8760 hours) and shall reflect *approved* coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location.

4. Ten or more thermal zones.

5. Thermal mass effects.

6. Hourly variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads.

7. Part-load performance curves for mechanical equipment.

8. Capacity and efficiency correction curves for mechanical heating and cooling equipment.

9. Printed *code official* inspection checklist listing each of the *proposed design* component characteristics from Table 506.5.1(1) determined by the analysis to provide compliance, along with their respective performance ratings (e.g., *R*-value, *U*-factor, SHGC, HSPF, AFUE, SEER, EF, etc.).

~~**506.6.1 Specific approval.** Performance analysis tools meeting the applicable subsections of Section 506 and tested according to ASHRAE Standard 140 shall be permitted to be *approved*. Tools are permitted to be *approved* based on meeting a specified threshold for a jurisdiction. The *code official* shall be permitted to approve tools for a specified application or limited scope.~~

506.6.1 Roof/Ceiling Thermal Envelopes. The roof or ceiling which functions as the building's thermal envelope shall be insulated to an R-value of at least R-10. Multiple-family residential roofs/ceilings shall be insulated to an R-value of at least R-19, space permitting. Where cavities beneath a roof deck are ventilated, the ceiling shall be considered the envelope component utilized in the EnergyGauge Summit Fla/Com calculation.

506.6.2 Input values. When calculations require input values not specified by Sections 502, 503, 504 and 505, those input values shall be taken from an *approved* source.

[NOTE: THIS TABLE IS UNDER CONSTRUCTION. FLORIDA'S STANDARD REFERENCE DESIGN VALUES ARE THOSE FOR THE 2007 CODE, WHICH IS BASED ON CHAPTER 11 OF ASHRAE STANDARD 90.1, 2004. THIS TABLE SHOULD REFLECT THOSE VALUES.]

TABLE 506.5.1(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT/ CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Space use classification	Same as proposed	The space use classification shall be chosen in accordance with Table 505.5.2 for all areas of the building covered by this permit. Where the space use classification for a building is not known, the building shall be categorized as an office building.
Roofs	Type: Insulation entirely above deck	As proposed
	Gross area: same as proposed	As proposed
	U-Factor: from Table 502.1.2	As proposed
	Solar Absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, above-grade	Type: Mass wall if proposed wall is mass; otherwise steel-framed wall	As proposed
	Gross Area: same as proposed	As proposed
	U-Factor: from Table 502.1.2	As proposed
	Solar Absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, below-grade	Type: Mass wall	As proposed
	Gross Area: same as proposed	As proposed
	U-Factor: from Table 502.1.2 with insulation layer on interior side of walls	As proposed
Floors, above-grade	Type: joist/framed floor	As proposed
	Gross Area: same as proposed	As proposed
	U-Factor: from Table 502.1.2	As proposed
Floors, slab-on-grade	Type: Unheated	As proposed
	F-Factor: from Table 502.1.2	As proposed
Doors	Type: Swinging	As proposed
	Area: Same as proposed	As proposed
	U-Factor: from Table 502.2(1)	As proposed
Glazing	Area: (a) The proposed glazing area; where the proposed glazing area is less than 40 % of above-grade wall area (b) 40 % of above-grade wall area; where the proposed glazing area is 40 % or more of the above-grade wall Area	As proposed
	U-factor: from Table 502.3	As proposed
	SHGC: from Table 502.3 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
	External Shading and PF: None	As proposed
Skylights	Area: (a) The proposed skylight area; where the proposed skylight area is less than 3 percent of gross area of roof assembly (b) 3 percent of gross area of roof assembly; where the proposed skylight area is 3 percent or more of gross area of roof assembly	As proposed
	U-factor: from Table 502.3	As proposed
	SHGC: from Table 502.3 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
Lighting, interior	The interior lighting power shall be determined in accordance with Table 505.5.2. Where the occupancy of the building is not known, the lighting power density shall be 1.0 Watt per square foot (10.73 W/m_2) based on the categorization of buildings with unknown	As proposed

	space classification as offices	
Lighting, exterior	The lighting power shall be determined in accordance with Table 505.6.2. Areas and dimensions of tradable and non-tradable surfaces shall be the same as proposed.	As proposed
Internal gains	Same as proposed	Receptacle, motor and process loads shall be modeled and estimated based on the space use classification. All end-use load components within and associated with the building shall be modeled to include, but not limited to the following: exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators, escalators, refrigeration equipment and cooking equipment.
Schedules	Same as proposed	Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays, and any seasonal operation. Schedules shall model the time-dependant variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage, and any process loads. The schedules shall be typical of the proposed building type as determined by the designer and approved by the jurisdiction.
Mechanical Ventilation	Same as proposed	As proposed, in accordance with Section 503.2.5.
Heating systems	Fuel Type: same as proposed design	As proposed
	Equipment Type[1]: from Table 506.5.1(2) and Table 506.5.1(3)	As proposed
	Efficiency: from Table 503.2.3(4) and Table 503.2.3(5)	As proposed
	Capacity[2]: sized proportionally to the capacities in the proposed design based on sizing runs, and shall be established such that no smaller number of unmet heating load hours and no larger heating capacity safety factors are provided than in the proposed design.	As proposed
Cooling systems	Fuel Type: same as proposed design	As proposed
	Equipment Type[3]: from Table 506.5.1(2) and Table 506.5.1(3)	As proposed
	Efficiency: from Table 503.2.3(1), Table 503.2.3(2) and Table 503.2.3(3)	As proposed
	Capacity[5]: sized proportionally to the capacities in the proposed design based on sizing runs, and shall be established such that no smaller number of unmet cooling load hours and no larger cooling capacity safety factors are provided than in the proposed design.	As proposed
	Economizer[4]: same as proposed, in accordance with Section 503.4.1	As proposed
Service water heating	Fuel type: same as proposed	As proposed
	Efficiency: from Table 504.2	As proposed
	Capacity: same as proposed	As proposed
	Where no service water hot water system exists or is specified in the proposed design, no service hot water heating shall be modeled	

~~1 Where no heating system exists or no heating system has been specified, the heating system shall be modeled as ***fossil fuel***. **[SWAMI: Do we do this?]** The system characteristics shall be identical in both the *Standard Reference Design* and *Proposed Design*.~~
~~2 The ratio between the capacities used in the annual simulations and the capacities determined by sizing runs shall be the same for both the *Standard Reference Design* and *Proposed Design*.~~
~~3 Where no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per thermal zone. The system characteristics shall be identical in both the *Standard Reference Design* and *Proposed Design*.~~
~~4 If an economizer is required as per Table 503.3.1 (1), and if no economizer exists or is specified in the *proposed design*, then a supply air economizer shall be provided in accordance with Section 503.4.1.~~

TABLE 506.5.1(2)
HVAC SYSTEMS MAP

Condenser Cooling Source[a]	**Heating System Classification**[b]	***Standard Reference Design* HVC System Type**[c] **Single Zone Residential System**	**Single Zone Non-Residential System**	**All Other**
Water/Ground	Electric Resistance	System 5	System 5	System 1
	Heat Pump	System 6	System 6	System 6
	Fossil Fuel	System 7	System 7	System 2
Air/None	Electric Resistance	System 8	System 9	System 3
	Heat Pump	System 8	System 9	System 3
	Fossil Fuel	System 10	System 11	System 4

a. Select "Water/Ground" if the *proposed design* system condenser is water or evaporatively cooled; select "Air/None" if the condenser is air-cooled. Closed-circuit drycoolers shall be considered air-cooled. Systems utilizing district cooling shall be treated as if the condenser water type were "water." If no mechanical cooling is specified or the mechanical cooling system in the *proposed design* does not require heat rejection, the system shall be treated as if the condenser water type were "Air." For proposed designs with ground-source or groundwater-source heat pumps, the standard reference design HVAC system shall be water-source heat pump (System 6).
b. Select the path that corresponds to the *proposed design* heat source: electric resistance, heat pump (including airsource and water-source), or fuel-fired. Systems utilizing district heating (steam or hot water) shall be treated as if the heating system type were "Fossil Fuel." Systems with no heating capability shall be treated as if the heating system type were "Fossil Fuel." For systems with mixed fuel heating sources, the system or systems that use the secondary heating source type (the one with the smallest total installed output capacity for the spaces served by the system) shall be modeled identically in the *standard reference design* and the primary heating source type shall be used to determine standard reference design HVAC system type.
c. Select the *standard reference design* HVAC system category: The system under "Single Zone Residential System" shall be selected if the HVAC system in the proposed design is a single-zone system and serves a residential space. The system under "Single Zone Nonresidential System" shall be selected if the HVAC system in the proposed design is a single-zone system and serves other than residential spaces. The system under "All Other" shall be selected for all other cases.

TABLE 506.5.1(3)
SPECIFICATIONS FOR THE STANDARD REFERENCE DESIGN HVAC SYSTEM DESCRIPTIONS

System No.	**System Type**	**Fan Control**	**Cooling Type**	**Heating Type**
1	Variable air volume with parallel fan-powered boxes a	VAV d	Chilled Water e	Electric Resistance
2	Variable air volume with reheat b	VAV d	Chilled Water e	Hot Water Fossil Fuel Boiler f
3	Packaged variable air volume with parallel fan-powered boxes a	VAV d	Direct Expansion c	Electric Resistance
4	Packaged variable air volume	VAV d	Direct	Hot Water Fossil Fuel

	with reheat b		Expansionc	Boiler f
5	Two-pipe fan-coil	Constant Volume i	Chilled Water e	Electric Resistance
6	Water-source heat pump	Constant Volume i	Direct Expansionc	Electric Heat Pump and Boiler g
7	Four-pipe fan coil	Constant Volume i	Chilled Water e	Hot Water Fossil Fuel Boiler f
8	Packaged terminal heat pump	Constant Volume i	Direct Expansionc	Electric Heat Pump h
9	Packaged rooftop heat pump	Constant Volume i	Direct Expansion c	Electric Heat Pump h
10	Packaged terminal air conditioner	Constant Volume i	Direct Expansion	Hot Water Fossil Fuel Boiler f
11	Packaged rooftop air conditioner	Constant Volume i	Direct Expansion	Fossil Fuel Furnace

a. VAV with parallel boxes: Fans in parallel VAV fan-powered boxes shall be sized for 50% of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume setpoints for fan-powered boxes shall be equal to the minimum rate for the space required for ventilation consistent with 503.4.5 Exception (5) 1. Supply air temperature setpoint shall be constant at the design condition.
b. VAV with reheat: Minimum volume setpoints for VAV reheat boxes shall be 0.4 cfm/ft2 of floor area. Supply air temperature shall be reset based on zone demand from the design temperature difference to a 10°F temperature difference under minimum load conditions. Design air flow rates shall be sized for the reset supply air temperature, i.e., a 10°F temperature difference.
c. Direct Expansion: The fuel type for the cooling system shall match that of the cooling system in the *proposed design*.
d. VAV: Constant volume can be modeled if the system qualifies for Exception (1) to 503.4.5. When the *proposed design* system has a supply, return, or relief fan motor 25 hp or larger, the corresponding fan in the VAV system of the *standard reference design* shall be modeled assuming a variable speed drive. For smaller fans, a forwardcurved centrifugal fan with inlet vanes shall be modeled. If the *proposed design's* system has a direct digital control system at the zone level, static pressure setpoint reset based on zone requirements in accordance with 503.4.2 shall be modeled.
e. Chilled Water: For systems using purchased chilled water, the chillers are not explicitly modeled and chilled water costs shall be based as determined in 506.3 and 506.5.2. Otherwise, the *standard reference design's* chiller plant shall be modeled with chillers having the number as indicated in Table 506.5.1(4) as a function of *standard reference building* chiller plant load and type as indicated in Table 506.5.1(5) as a function of individual chiller load. Where chiller fuel source is mixed, the system in the *standard reference design* shall have chillers with the same fuel types and with capacities having the same proportional capacity as the *proposed design's* chillers for each fuel type. Chilled water supply temperature shall be modeled at 44°F design supply temperature and 56°F return temperature. Piping losses shall not be modeled in either building model. Chilled water supply water temperature shall be reset in accordance with 503.4.3.4. Pump system power for each pumping system shall be the same as the *proposed design*; if the *proposed design* has no chilled water pumps, the *standard reference design* pump power shall be 22 W/gpm (equal to a pump operating against a 75 ft head, 65% combined impeller and motor *efficiency*). The chilled water system shall be modeled as primary-only variable flow with flow maintained at the design rate through each chiller using a bypass. Chilled water pumps shall be modeled as riding the pump curve or with variable-speed drives when required in 503.4.3.4. The heat rejection device shall be an axial fan cooling tower with two-speed fans if required in 503.4.4. Condenser water design supply temperature shall be 85°F or 10°F approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F. The tower shall be controlled to maintain a 70°F leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. Pump system power for each pumping system shall be the same as the *proposed design*; if the *proposed design* has no condenser water pumps, the *standard reference design* pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% combined impeller and motor *efficiency*). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

f. Fossil Fuel Boiler: For systems using purchased hot water or steam, the boilers are not explicitly modeled and hot water or steam costs shall be based on actual utility rates. Otherwise, the boiler plant shall use the same fuel as the *proposed design* and shall be natural draft. The *standard reference design* boiler plant shall be modeled with a single boiler if the *standard reference design* plant load is 600,000 Btu/h and less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Hot water supply temperature shall be modeled at 180°F design supply temperature and 130°F return temperature. Piping losses shall not be modeled in either building model. Hot water supply water temperature shall be reset in accordance with 503.4.3.4. Pump system power for each pumping system shall be the same as the *proposed design*; if the *proposed design* has no hot water pumps, the *standard reference design* pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% combined impeller and motor *efficienc*y). The hot water system shall be modeled as primary-only with continuous variable flow. Hot water pumps shall be modeled as riding the pump curve or with variable speed drives when required by 503.4.3.4.

g. Electric Heat Pump and Boiler: Water-source heat pumps shall be connected to a common heat pump water loop controlled to maintain temperatures between 60°F and 90°F. Heat rejection from the loop shall be provided by an axial fan closed-circuit evaporative fluid cooler with two-speed fans if required in 503.4.2. Heat addition to the loop shall be provided by a boiler that uses the same fuel as the *proposed design* and shall be natural draft. If no boilers exist in the *proposed design*, the standard reference building boilers shall be fossil fuel. The *standard reference design* boiler plant shall be modeled with a single boiler if the *standard reference design* plant load is 600,000 Btu/h or less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Piping losses shall not be modeled in either building model. Pump system power shall be the same as the *proposed design*; if the *proposed design* has no pumps, the *standard reference design* pump power shall be 22 W/gpm, which is equal to a pump operating against a 75 foot head, with a 65% combined impeller and motor *efficiency*. Loop flow shall be variable with flow shutoff at each heat pump when its compressor cycles off as required by 503.4.3.3. Loop pumps shall be modeled as riding the pump curve or with variable speed drives when required by 503.4.3.4.

h. Electric Heat Pump: Electric air-source heat pumps shall be modeled with electric auxiliary heat. The system shall be controlled with a multi-stage space thermostat and an *outdoor air* thermostat wired to energize auxiliary heat only on the last thermostat stage and when *outdoor air* temperature is less than 40°F.

i. Constant Volume: Fans shall be controlled in the same manner as in the *proposed design*; i.e., fan operation whenever the space is occupied or fan operation cycled on calls for heating and cooling. If the fan is modeled as cycling and the fan energy is included in the energy *efficiency* rating of the equipment, fan energy shall not be modeled explicitly.

TABLE 506.5.1(4)
NUMBER OF CHILLERS

TOTAL CHILLER PLANT CAPACITY	NUMBER OF CHILLERS
≤300 tons	1
>300 tons, < 600 tons	2 sized equally
≥600 tons	2 minimum with chillers added so that no chiller is larger than 800 tons, all sized equally

TABLE 506.5.1(5)
WATER CHILLER TYPES

INDIVIDUAL CHILLER PLANT CAPACITY	ELECTRIC CHILLER TYPE	FOSSIL FUEL CHILLER TYPE
≤100 tons	Reciprocating	Single-effect absorption, direct fired
>100 tons, <300 tons	Screw	Double-effect absorption, direct fired
≥300 tons	Centrifugal	Double-effect absorption, direct fired