CHAPTER 8

BUILDING DESIGN FOR COMMERCIAL BUILDINGS

The following modifications are made pursuant to the National Appliance Energy Conservation Act of 1987 (NAECA). Single-phase air-cooled air conditioners < 65,000 Btu/h SEER values are those set by NAECA. Single-phase air-cooled heat pumps < 65,000 Btu/h SEER and HSPF values are those set by NAECA.

SECTION 801
GENERAL

801.1 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 90.1-2004 or the requirements contained in this chapter.

801.2 Application. The requirements in Sections 802, 803, 804, 805 and 806 shall each be satisfied on an individual basis. Where one or more of these sections is not satisfied, compliance for that section(s) shall be demonstrated in accordance with the applicable provisions of ASHRAE/IESNA 90.1-2004.

801.2.1 Applicable provisions.

1. ASHRAE/IESNA 90.1-2004 Section 5, *Building Envelope Requirement*. Vermont, Burlington WSO AP Location. All envelope requirements under ASHRAE/IESNA 90.1-2004 shall comply with 2005 *Vermont Guidelines for Energy Efficient Commercial Construction* Table 802.2(1), Building Envelope Requirements – Opaque Elements, and Table 802.2(2), Building Envelope Requirements – Fenestration.
2. ASHRAE/IESNA 90.1-2004, Section 10.3, Transformer Requirements as follows: All liquid-filled and dry-type transformers shall comply with 2005 *Vermont Guidelines for Energy Efficient Commercial Construction* Section 806.3, Transformers.
3. ASHRAE/IESNA 90.1-2004 Section 11.1.5, Paragraph (a) as follows: The annual energy use (Btuh/ft^2-yr) and associated energy cost budget for the budget building design and the annual energy use (Btuh/ft^2-yr) and associated design energy cost for the proposed design.
4. ASHRAE/IESNA 90.1-2004, Section 6.2.3 Electric Resistance Space Heating. Building heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, domestic hot water heaters and coils in terminal units and air systems is prohibited.

   Exceptions to 6.2.3:

   a. Areas, such as stairways, that cannot be penetrated with piping or duct and no other method of heating is possible,
   b. Where authority having jurisdiction expressly allows,
   c. Replacement of existing electrical resistance unit,
   d. Special conditions of occupancy or use that require electrical resistance heat to maintain health, safety or environmental conditions,
   e. Limited areas where demonstrated to be a practical application of resistance electrical heat (e.g., small interior space such as a rest room which is distant from the heat distribution system, hazardous material storerooms, stairwell or other means of emergency egress),
   f. Domestic hot water heaters less than 5 kW in total unit input capacity.
5. a. Amend ASHRAE/IESNA 90.1-2004, Section 6.3.2 (d) by deleting "an electric resistance heater,"
   b. Delete ASHRAE/IESNA 90.1-2004, Section 6.3.2 (g)
   c. Delete ASHRAE/IESNA 90.1-2004, Section 6.4.3.4
6. Amend ASHRAE/IESNA 90.1-2004, Table 7.8 first row size category to < = 5 kW; and delete second row size category <12 kW.

SECTION 802
BUILDING ENVELOPE REQUIREMENTS

802.1 General. Walls, roof assemblies, floors, glazing and slabs on grade which are part of the building envelope for buildings shall meet the requirements of Sections 802.2.1 through 802.2.9, as applicable. ASHRAE/IESNA 90.1-2004, Section 11, Energy Cost Budget Method, must be used for buildings with vertical fenestration more than 50 percent of gross above-grade wall area.

802.1.1 Classification of walls. Walls associated with the building envelope shall be classified in accordance with Section 802.1.1.1, 802.1.1.2 or 802.1.1.3.

802.1.1.1 Above-grade walls. Above-grade walls are those walls covered by Section 802.2.1 on the exterior of the building and completely above grade or walls that are more than 15 percent above grade.

802.1.1.2 Below-grade walls. Below-grade walls covered by Section 802.2.8 are basement or first-story walls associated with the exterior of the building that are at least 85 percent below grade.

802.1.1.3 Interior walls. Interior walls covered by Section 802.2.9 are those walls not on the exterior of the building and that separate conditioned and unconditioned space.

802.1.2 Moisture control. Framed walls, floors and ceilings not ventilated to allow moisture to escape shall have installed an approved vapor retarder having a permeance rating of 1 perm (5.7×10^{-11} kg/Pa · s · m^2) or less when

tested in accordance with the dessicant method using Procedure A of ASTM E 96. The vapor retarder shall be installed on the warm-in-winter side of the insulation.

Exceptions:

1. In construction where moisture or its freezing will not damage the materials.
2. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are installed.

802.2 Criteria. The building envelope components shall meet each of the applicable requirements in Tables 802.2(1), 802.2(2), and 802.2(3) based on the percentage of wall that is glazed. The percentage of wall that is glazed shall be determined by dividing the aggregate area of rough openings for glazing (windows and glazed doors) in all above-grade walls associated with the building envelope by the total gross area of all above-grade exterior walls that are a part of the building envelope. In buildings with multiple types of building envelope construction, each building envelope construction type shall be evaluated separately. Where Table 802.2(1), 802.2(2), or 802.2(3) does not list a particular construction type, the applicable provisions of ASHRAE/IESNA 90.1-2004 shall be used in lieu of Section 802.

802.2.1 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 802.2(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 802.2(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).

802.2.2 Opaque doors. Opaque doors (doors having less than 50 percent glass area) shall meet the applicable requirements for doors as specified in Table 802.2(1) and be considered as part of the gross area of above-grade walls that are part of the building envelope.

802.2.3 Windows and glass doors. The maximum solar heat gain coefficient (SHGC) and thermal transmittance (*U*-factor) of window assemblies and glass doors located in the building envelope shall be as specified in Table 802.2(2), based on the window projection factor.

The window projection factor shall be determined in accordance with Equation 8-1.

$$PF = H/V \qquad \textbf{(Equation 8-1)}$$

where:

PF = Projection factor (decimal) (Figure 802.2.3).

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

V = 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.

802.2.4 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 802.2.(1), based on construction materials used in the roof assembly.

Exception: Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25.4 mm) or less and where the area weighted *U*-factor is equivalent to the same assembly with the *R*-value specified in Table 802.2(1).

Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation.

802.2.5 Skylights. Skylights located in the building envelope shall be limited to 5 percent of the gross roof assembly area and shall have a maximum thermal transmittance (*U*-factor) and SHGC of the skylight assembly as specified in Table 802.2(2).

802.2.6 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 802.2(1), based on construction materials used in the floor assembly.

802.2.7 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 802.2(1). The insulation shall be placed on the outside of the foundation or on the inside of the 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.

802.2.8 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 802.2(1), and shall extend to a depth of 10 feet (3048 mm) below the outside finish ground level, or to the level of the floor, whichever is less.

802.2.9 Interior walls. The minimum thermal resistance (*R*-value) of the insulating material installed in the wall cavity or continuously on the interior walls shall be the same as that specified for above-grade walls in Table 802.2(1).

802.3 Air leakage. The requirements for air leakage shall be as specified in Sections 802.3.1 through 802.3.7.

TABLE 802.2(1)
BUILDING ENVELOPE REQUIREMENTS – OPAQUE ELEMENTS

Buildings with vertical fenestration 50 percent maximum of gross above-grade wall area (Buildings with window and door glazed area more than 50 percent of the gross above-grade wall area shall meet the applicable provisions of ASHRAE/IESNA 90.1-2004 Section 11, Energy Cost Budget Method)		
	Maximum Overall Factor for Entire Assembly	**Minimum *R*-values are for Added Insulation**
Roofs		
Insulation entirely above deck	U - 0.040	R-24 ci
Metal building[a]	U - 0.051	R-19 + R-10 (with R-5 thermal blocks)[b] or R-30 (with R-5 thermal blocks)[b]
Steel joist	U - 0.027	R-30 + R-5 ci (with R-5 thermal blocks)
Attic and other	U - 0.027	R-38
Walls, Above Grade		
Mass	U - 0.104	R-9.5 ci
Metal building[a]	U - 0.070	R-19 or R-6 + R-13
Metal framed	U - 0.064	R-13 + R-7.5 ci
Wood framed and other	U - 0.064	R-19 or R-12 ci or R-13 + R-3.8 ci
Walls, Below Grade		
Below grade wall[c]	C - 0.092	R-10 ci
Floors		
Mass	U - 0.074	R-10 ci
Steel joist	U - 0.038	R-30
Wood frame and other	U - 0.033	R-30
Slab-on-Grade Floors		
Unheated Slabs	F - 0.64	R-10 for 48 inches
Heated Slabs	F - 0.55	R-10 for entire slab (under slab and perimeter)
Opaque Doors		
Swinging	U-0.50	NR
Roll-up or sliding	NR	R-10

For SI: 1 inch = 25.4 mm.
ci = Continuous Insulation
NR = No Requirement

a. Assembly descriptions can be found in Table 802.2(3), Page 17.

b. Thermal blocks are a minimum R-5 of rigid insulation, which extends 1-inch beyond the width of the purlin on each side, perpendicular to the purlin.

c. 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.

TABLE 802.2(2)
BUILDING ENVELOPE REQUIREMENTS – FENESTRATION

Vertical Fenestration (50% maximum of gross above-grade wall area)	
SHGC – All Frame Types	
SHGC: PF < 0.25	0.40
SHGC: 0.25 < PF < 0.5	0.55
SHGC: PF ≥ 0.5	NR
Framing Materials other than Metal with or without Metal Reinforcement or cladding	
U-Factor	0.35
Metal framing with or without Thermal Break	
Curtain Wall/Storefront U-Factor	0.45
Entrance Door *U*-Factor	0.80
All Other *U*-Factor	0.50
Skylights (5% maximum of the gross roof area)	
Glass	
U-Factor	0.60
SHGC	0.40
Plastic	
U-Factor	0.60
SHGC	0.62

NR = No requirement.
PF = Projection factor (See Section 802.2.3)
SHGC = (See Section 202)

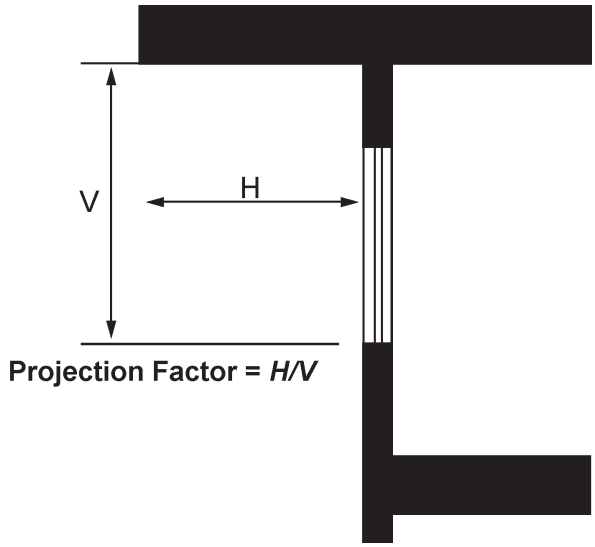

Figure 802.2.3
PROJECTION FACTOR

802.3.1 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 101/I.S.2 or AAMA/WDMA 101/I.S.2/NAFS, or NFRC 400 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Windows, skylights and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm/ft^2 (1.5 L/s/m^2) and swinging doors no more than 0.5 cfm/ft^2 (2.6 L/s/m^2).

Exception: Site-constructed windows and doors that are weatherstripped or sealed in accordance with Section 802.3.3.

802.3.2 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.

802.3.3 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.

802.3.4 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/ft^2

TABLE 802.2(3)
METAL BUILDING ASSEMBLY DESCRIPTIONS

Roofs	DESCRIPTION	REFERENCE
R-19 + R-10	Filled cavity roof Thermal blocks are a minimum R-5 of rigid insulation, which extends 1 in. beyond the width of the purlin on each side, perpendicular to the purlin. This construction is R-10 insulation batts draped perpendicularly over the purlins, with enough looseness to allow R-19 batt to be laid above it, parallel to the purlins. Thermal blocks are then placed above the purlin/batt, and the roof deck is secured to the purlins. In the metal building industry, this is known as the "sag and bag" insulation system.	ASHRAE/IESNA 90.1-2004 Table A2.3
R-30	Standing seam with single insulation layer Thermal blocks are a minimum R-5 of rigid insulation, which extends 1 in. beyond the width of the purlin on each side, perpendicular to the purlin. This construction is R-30 insulation batts draped perpendicularly over the purlins or hung between the purlins. Thermal blocks are then placed above the purlin/batt, and the roof deck is secured to the purlins.	—
Walls		
R-6 + R-13	Double insulation layer The first layer of R-6 insulation batts is installed continuously perpendicular to the girts, and is compressed as the metal skin is attached to the girts. The second layer of R-13 insulation batts is installed within the framing cavity.	ASHRAE/IESNA 90.1 Table A3.2
R-19	Single insulation layer The first layer of R-19 insulation batts is installed continuously perpendicular to the girts, and is compressed as the metal skin is attached to the girts.	—

For SI: 1 inch = 25.4 mm.

(6.8 L/s · m^2) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with AMCA 500D.

Exception: Use of gravity (nonmotorized) dampers is permitted in buildings less than three stories in height above grade.

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

802.3.6 Vestibules. 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. Doors not intended for use as a building entrance door, such as doors to mechanical or electrical equipment rooms.
2. Doors opening directly from a guestroom or dwelling unit.
3. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area.
4. Revolving doors.
5. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

802.3.7 Recessed luminaires. When installed in the building envelope, recessed luminaires shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.
2. Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 0.5-inch-thick (12.7 mm) gypsum wallboard or constructed from a preformed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose, while maintaining required clearances of not less than 0.5 inch (12.7 mm) from combustible material and not less than 3 inches (76 mm) from insulation material.
3. Type IC rated, in accordance with ASTM E 283 admitting no more than 2.0 cubic feet per minute (cfm) (0.944 L/s) of air movement from the conditioned space to the ceiling cavity. The luminaire shall be tested at 1.57 psf (75 Pa) pressure difference and shall be labeled.

SECTION 803
BUILDING MECHANICAL SYSTEMS

803.1 General. This section covers the design and construction of mechanical systems and equipment serving the building heating, cooling or ventilating needs.

803.1.1 Compliance. Compliance with Section 803 shall be achieved by meeting either Section 803.2 or 803.3.

803.1.2 Electric resistance space heating. Building heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, domestic hot water heaters and coils in terminal units and air systems is prohibited.

Exceptions:

1. Areas, such as stairways, that cannot be penetrated with piping or duct and no other method of heating is possible.
2. Where authority having jurisdiction expressly allows.
3. Replacement of existing electrical resistance unit.
4. Special conditions of occupancy or use that require electrical resistance heat to maintain health, safety or environmental conditions.
5. Limited areas where a practical application of resistance electrical heat is demonstrated (e.g. small interior space such as a rest room which is distant from the heat distribution system, hazardous material storerooms, stairwell or other means of emergency egress).
6. Domestic hot water heaters less than 5 kW in total unit input capacity.

803.2 Simple HVAC systems and equipment. This section applies to buildings served by unitary or packaged HVAC equipment listed in Tables 803.2.2(1) through 803.2.2(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 803.3.

803.2.1 Calculation of heating and cooling loads. Design loads shall be determined in accordance with the procedures described in the ASHRAE *Fundamentals Handbook*. Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are used 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.

803.2.1.1 Equipment and system sizing. Heating and cooling equipment and systems capacity shall not exceed the loads calculated in accordance with Section 803.2.1. 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.

803.2.2 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables 803.2.2(1), 803.2.2(2), 803.2.2(3), 803.2.2(4) and 803.2.2(5) when tested and rated in accordance with the applicable test procedure. The efficiency shall be verified through data furnished by the manufacturer or through certification under an approved certification program. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements.

803.2.3 Temperature and humidity controls. Requirements for temperature and humidity controls shall be as specified in Sections 803.2.3.1 through 803.2.3.3.

803.2.3.1 Temperature controls. Each heating and cooling system shall have at least one solid-state programmable thermostat. The thermostat shall have the capability to set back or shut down the system based on day of the week and time of day, and provide a readily accessible manual override that will return to the presetback or preshutdown schedule without reprogramming.

Exceptions:

1. HVAC systems serving hotel/motel guest rooms.
2. Packaged terminal air conditioners, packaged terminal heat pumps and room air conditioner systems.

803.2.3.2 Humidity controls. When humidistats are installed, they shall have the capability to prevent the use of fossil fuel or electric power to achieve a humidity below 60 percent when the system controlled is cooling, and above 30 percent when the system controlled is heating.

Exceptions:

1. 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.
2. Systems where humidity is removed as the result of the use of a desiccant system with energy recovery.
3. Reheat systems using site-recovered (including condenser heat) or site-solar energy sources.

803.2.4 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 803.3.3.7.

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

TABLE 803.2.2(1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY 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 Btuh/h and < 135,000 Btu/h	Split system and single package	10.3 EER[c]	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.7 EER[c]	ARI 340/360
	≥ 240,000 Btu/h and < 760,000 Btu/h	Split system and single package	9.5 EER[c] 9.7 IPLV[c]	
	≥ 760,000 Btu/h	Split system and single package	9.2 EER[c] 9.4 IPLV[c]	
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	11.0 EER[c] 10.3 IPLV[c]	
Through-the-wall, Air cooled	≤ 30,000 Btu/h[c]	Split System	10.9 SEER 12.0 SEER (as of 1/23/2010)	ARI 210/240
		Single Package	10.6 SEER 12.0 SEER (as of 1/23/2010)	

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

a. Chapter 10 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. IPLVs are applicable only 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 the National Appliance Energy Conservation Act of 1987 (NAECA), SEER values are those set by NAECA.

TABLE 803.2.2(2)
UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Air cooled (Cooling mode)	< 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	10.1 EER[c]	
	≥135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.3 EER[c]	ARI 340/360
	≥ 240,000 Btu/h	Split system and single package	9.0 EER[c] 9.2 IPLV[c]	
Water source (Cooling mode)	< 17,000 Btu/h	86°F entering water	11.2 EER	ARI/ASHRAE-13256-1
	≥ 17,000 Btu/h and < 135,000 Btu/h	86°F entering water	12.0 EER	ARI/ASHRAE-13256-1
Groundwater source (Cooling mode)	< 135,000 Btu/h	59°F entering water	16.2 EER	ARI/ASHRAE-13256-1
Ground source (Cooling mode)	< 135,000 Btu/h	77°F entering water	13.4 EER	ARI/ASHRAE 13256-1
Air cooled (Heating mode)	< 65,000 Btu/h[d] (Cooling capacity)	Split system	7.7 HSPF	ARI 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	3.2 COP	
	≥ 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb outdoor air	3.1 COP	ARI 340/360
Water source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	68°F entering water	4.2 COP	ARI/ASHRAE-13256-1
Groundwater source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	50°F entering water	3.6 COP	ARI/ASHRAE-13256-1
Ground Source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	32°F entering water	3.1 COP	ARI/ASHRAE-13256-1
Through-the-wall (Air-cooled, cooling mode)	≤ 30,000 Btu/h[c]	Split System	10.9 SEER 12.0 SEER (as of 1/23/2010)	ARI 210/240
		Single Package	10.6 SEER 12.0 SEER (as of 1/23/2010)	
Through-the-wall, (Air-cooled, heating mode)	≤ 30,000 Btu/h[c] (cooling capacity)	Split System	7.1 HSPF 7.4 HSPF (as of 1/23/2010)	
		Single Package	7.0 HSPF 7.4 HSPF (as of 1/23/2010)	

For SI: °C = [(°F) - 32] / 1.8, 1 British thermal unit per hour = 0.2931 W.

db = dry-bulb temperature, °F wb = wet-bulb temperature, °F

a. Chapter 10 contains a complete specification of the referenced 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 heat pumps < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA), SEER and HSPF values are those set by NAECA.

TABLE 803.2.2(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 · Cap/1000) EER	ARI 310/380
PTAC (Cooling mode) Replacements[c]	All capacities	95°F db outdoor air	10.9 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) New construction	All capacities	95°F db outdoor air	12.3 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) Replacements[c]	All capacities	95°F db outdoor air	10.8 - (0.213 · Cap/1000) EER	
PTHP (Heating mode) New construction	All capacities	—	3.2 - (0.026 · Cap/1000) COP	
PTHP (Heating mode) Replacements[c]	All capacities	—	2.9 - (0.026 · Cap/1000) COP	

For SI: 1 inch = 25.4 mm, °C - [(°F) - 32] / 1.8, 1 British thermal unit per hour - 0.2931 W.

db = dry-bulb temperature, °F

wb = wet-bulb temperature, °F

a. Chapter 10 contains a complete specification of the referenced 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.

TABLE 803.2.2(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 (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY [d, e]	TEST PROCEDURE[a]
Warm air furnaces, gas fired	< 225,000 Btu/h	—	78% AFUE or 80% E_t[c]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity[c]	80% E_t[f]	ANSI Z21.47
Warm furnaces, 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 10 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 the National Appliance Energy Conservation Act of 1987(NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h) shall 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 jackets not exceeding 0.75 percent 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 drawing combustion air from the conditioned space.

g. E_t = Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75 percent 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 drawing combustion air from the conditioned space.

TABLE 803.2.2(5)
BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE[f]	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[c, d, e]	TEST PROCEDURE[a]
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 Btu/h	Minimum capacity[b]	75% E_t	H.I. HBS
	>2,500,000 Btu/h[f]	Hot water	80% E_c	
		Steam	80% E_c	
Boilers, Oil fired	< 300,000 Btu/h	—	80% AFUE	DOE 10 CFR Part 430
	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	Minimum capacity[b]	78% E_t	H.I. HBS
	> 2,500,000 Btu/h[f]	Hot water	83% E_c	
		Steam	83% E_c	
Boilers, Oil fired (Residual)	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	Minimum capacity[b]	78% E_t	H.I. HBS
	> 2,500,000 Btu/hf	Hot water	83% E_c	
		Steam	83% E_c	

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

a. Chapter 10 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

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

c. E_c = Combustion efficiency (100 percent flue losses). See reference document for detailed information.

d. E_t = Thermal efficiency. See reference document 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 packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

803.2.5.1 Energy recovery ventilation systems. Individual fan systems that have both a design supply air capacity of 5,000 cfm (2.36 m^3/s) or more and a minimum outside air supply of 70 percent or more of the design supply air quantity shall have an energy recovery system capable of changing the enthalpy of the outdoor air supply by 50 percent or more of the difference between the outdoor air and return air at design conditions. The system shall be capable of bypassing or controling the energy recovery system to permit cooling with outdoor air where cooling with outdoor air is required.

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

1. Where energy recovery systems are prohibited by the *International Mechanical Code*.
2. Laboratory fume hood systems with a total exhaust rate of 15,000 cfm (7.08 m^3/s) or less.
3. Laboratory fume hood systems with a total exhaust rate greater than 15,000 cfm (7.08 m^3/s) that include at least one of the following features:
   - 3.1 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.
   - 3.2 Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (Δ1.1°C) below room set point, cooled to no cooler than 3°F (Δ1.7°C) above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
4. Systems serving spaces that are not cooled and are heated to less than 60°F (15.5°C).
5. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
6. Systems requiring dehumidification that use series-style energy recovery coils wrapped around the cooling coil.

803.2.6 Cooling with outdoor air. Supply air economizers shall be installed on each cooling system (≥ 65,000 Btu/h).

Economizers shall be capable of supplying 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.

Exception: Systems with air- or evaporatively cooled condensers and which serve spaces with open case refrigeration or that require filtration equipment to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.

803.2.7 Shutoff dampers. Outdoor air supply and exhaust ducts shall have installed an automatic means to reduce and shut off airflow.

Exceptions:

1. Systems serving areas designed for continuous operation.
2. Individual systems with a maximum 3,000 cfm (1416 L/s) airflow rate.
3. Systems with readily accessible manual dampers.
4. Where restricted by health and life safety codes.

803.2.8 Duct and plenum insulation and sealing. All supply and return air ducts and plenums shall be insulated with a minimum of R-5 insulation when located in unconditioned spaces and with 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 (Δ8°C).

All joints, longitudinal and transverse seams and connections in ductwork, shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL 181A and shall be marked "181A-P" for pressure-sensitive tape, "181A-M" for mastic or "181A-H" for heat-sensitive tape. Tapes and mastics used to seal flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked "181B-FX" for pressure-sensitive tape or "181B-M" for mastic. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Unlisted duct tape is not permitted as a sealant on any duct.

803.2.8.1 Duct construction. Ductwork shall be constructed and erected in accordance with the *International Mechanical Code*.

803.2.8.1.1 High- and medium-pressure duct systems. All ducts and plenums operating at a static pressures greater than 2 inches w.g. (500 Pa) shall be insulated and sealed in accordance with Section 803.2.8. Ducts operating at a static pressures in excess of 3 inches w.g. (750 Pa) shall be leak tested in accordance with Section 803.3.6. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

803.2.8.1.2 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 applied 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 *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.

803.2.9 Piping insulation. Piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Section 803.3.7.

803.3 Complex HVAC systems and equipment. This section applies to buildings served by HVAC equipment and systems not covered in Section 803.2.

803.3.1 Calculation of heating and cooling loads. Design loads shall be determined in accordance with Section 803.2.1.

803.3.1.1 Equipment and system sizing. Heating and cooling equipment and system capacity shall not exceed the loads calculated in accordance with Section 803.2.1.

Exceptions:

1. Required standby equipment and systems equipped with controls and devices that allow the 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 having controls that are capable of sequencing the operation of each unit based on load.

803.3.2 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables 803.3.2(1) through 803.3.2(6) and Table 803.2.2(5) 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 stated, the equipment shall satisfy all those 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 demonstrate that the combined efficiency of the specified components meets the requirements herein.

TABLE 803.3.2(1)
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	ARI 365
Condensing units Water or evaporatively cooled	≥ 135,000 Btu/h	13.1 EER 13.1 IPLV	

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

a. Chapter 10 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

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

TABLE 803.3.2(2)
WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Air cooled, with condenser, electrically operated	< 150 tons	2.80 COP 2.80 IPLV	ARI 550/590
	≥ 150 tons	2.50 COP 2.50 IPLV	
Air cooled, without condenser, electrically operated	All capacities	3.10 COP 3.10 IPLV	ARI 550/590
Water cooled, electrically operated, Positive displacement (reciprocating)	All capacities	4.20 COP 4.65 IPLV	
Water cooled, electrically operated, Positive displacement (rotary screw and scroll)	< 150 tons	4.45 COP 4.50 IPLV	ARI 550/590
	≥ 150 tons and < 300 tons	4.90 COP 4.95 IPLV	
	≥ 300 tons	5.50 COP 5.60 IPLV	
Water cooled, electrically operated, centrifugal	< 150 tons	5.00 COP 5.00 IPLV	ARI 550/590
	≥ 150 tons and < 300 tons	5.55 COP 5.55 IPLV	
	≥ 300 tons	6.10 COP 6.10 IPLV	
Air cooled, absorption single effect	All capacities	0.60 COP	ARI 560
Water cooled, absorption single effect	All capacities	0.70 COP	
Absorption double effect, indirect-fired	All capacities	1.00 COP 1.05 IPLV	
Absorption double effect, direct-fired	All capacities	1.00 COP 1.00 IPLV	

For SI: 1 ton = 3.517 kW, °C = [(°F) - 32]/1.8.

a. Chapter 10 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. The chiller equipment requirements do not apply for chillers used in low temperature applications where the design leaving fluid temperature is less than or equal to 40°F.

Where unitary or prepackaged equipment is used in a complex HVAC system and is not covered by Section 803.3.2, the equipment shall meet the applicable requirements of Section 803.2.2.

Exception: Equipment listed in Table 803.3.2(2) not designed for operation at ARI Standard test conditions of 44°F (7°C) leaving chilled water temperature and 85°F (29°C) entering condenser water temperature shall have a minimum full load COP and IPLV rating as shown in Tables 803.3.2(3) through 803.3.2(5), as applicable. The table values are applicable only over the following full load design ranges:

Leaving Chilled
Water Temperature: 40 to 48°F (4 to 9°C)

Entering Condenser
Water Temperature: 75 to 85°F (24 to 29°C)

Condensing Water
Temperature Rise: 5 to 15°F (Δ3 to Δ8°C)

Chillers designed to operate outside of these ranges are not covered by this code.

803.3.3 HVAC system controls. Each heating and cooling system shall be equipped with thermostatic controls as required in Sections 803.3.3.1 through 803.3.3.8.

803.3.3.1 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 installed for each humidity control system

TABLE 803.3.2(3)
COPs AND IPLVs FOR NONSTANDARD CENTRIFUGAL CHILLERS < 150 TONS

CENTRIFUGAL CHILLERS < 150 TONS COP_{std} = 5.4								
Leaving chilled water temperature (°F)	Entering condenser water temperature (°F)	Lift[a] (°F)	Condenser flow rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP and IPLV					
46	75	29	6.00	6.27	6.48	6.80	7.03	7.20
45	75	30	5.92	6.17	6.37	6.66	6.87	7.02
44	75	31	5.84	6.08	6.26	6.53	6.71	6.86
43	75	32	5.75	5.99	6.16	6.40	6.58	6.71
42	75	33	5.67	5.90	6.06	6.29	6.45	6.57
41	75	34	5.59	5.82	5.98	6.19	6.34	6.44
40	75	35	5.50	5.74	5.89	6.10	6.23	6.33
46	80	34	5.59	5.82	5.98	6.19	6.34	6.44
45	80	35	5.50	5.74	5.89	6.10	6.23	6.33
44	80	36	5.41	5.66	5.81	6.01	6.13	6.22
43	80	37	5.31	5.57	5.73	5.92	6.04	6.13
42	80	38	5.21	5.48	5.64	5.84	5.95	6.04
41	80	39	5.09	5.39	5.56	5.76	5.87	5.95
40	80	40	4.96	5.29	5.47	5.67	5.79	5.86
46	85	39	5.09	5.39	5.56	5.76	5.87	5.95
45	85	40	4.96	5.29	5.47	5.67	5.79	5.86
44	85	41	4.83	5.18	5.40	5.59	5.71	5.78
43	85	42	4.68	5.07	5.28	5.50	5.62	5.70
42	85	43	4.51	4.94	5.17	5.41	5.54	5.62
41	85	44	4.33	4.80	5.05	5.31	5.45	5.53
40	85	45	4.13	4.65	4.92	5.21	5.35	5.44
Condenser ΔT[b]			14.04	11.23	9.36	7.02	5.62	4.68

For SI: °C = [(°F) - 32] / 1.8, 1 gallon per minute = 3.785 L/min., 1 ton = 12,000 British thermal units per hour = 3.517 kW.

a. Lift = [Entering condenser water temperature (°F) - Leaving chilled water temperature (°F)].

b. Condenser ΔT = [Leaving condenser water temperature (°F) - Entering condenser water temperature (°F)].

$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)$

where: X = Condenser ΔT + Lift

$COP_{adj} = K_{adj} \times COP_{std}$

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.

803.3.3.2 Set point overlap restriction. Where used to control both heating and cooling, zone thermostatic controls shall maintain a temperature range or deadband of at least 5°F (Δ2.8°C) within which the supply of heating and cooling energy to the zone can be shut off or reduced to a minimum.

Exception: Thermostats requiring manual changeover between heating and cooling modes.

803.3.3.3 Off-hour controls. Each zone shall have thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

TABLE 803.3.2(4)
COPs AND IPLVs FOR NONSTANDARD CENTRIFUGAL CHILLERS ≥ 150 TONS, ≤ 300 TONS

CENTRIFUGAL CHILLERS ≥ 150 Tons, ≤ 300 Tons COP_{std} = 5.55								
Leaving chilled water temperature (°F)	Entering condenser water temperature (°F)	Lift[a] (°F)	Condenser flow rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP and IPLV					
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22
44	75	31	6.00	6.24	6.43	6.71	6.90	7.05
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75
41	75	34	5.74	5.98	6.14	6.36	6.51	6.62
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51
46	80	34	5.74	5.98	6.14	6.36	6.51	6.62
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30
42	80	38	5.35	5.64	5.8	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11
45	85	40	5.10	5.44	5.62	5.83	5.95	6.03
44	85	41	4.96	5.33	5.55	5.74	5.86	5.94
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59
Condenser ΔT[b]			14.04	11.23	9.36	7.02	5.62	4.68

For SI: °C = [(°F) - 32] / 1.8, 1 gallon per minute = 3.785 L/min., 1 ton = 12,000 British thermal units per hour = 3.517 kW.

a. Lift = [Entering condenser water temperature (°F) - Leaving chilled water temperature (°F)].

b. Condenser ΔT = [Leaving condenser water temperature (°F) - Entering condenser water temperature (°F)].

$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)$

where: X = Condenser ΔT + Lift $COP_{adj} = K_{adj} \times COP_{std}$

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.

803.3.3.3.1 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).

803.3.3.3.2 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.

TABLE 803.3.2(5)
COPs AND IPLVs FOR NONSTANDARD CENTRIFUGAL CHILLERS > 300 TONS

CENTRIFUGAL CHILLERS > 300 Tons COP_{std} = 6.1								
			Condenser flow rate					
Leaving chilled water temperature (°F)	Entering condenser water temperature (°F)	Lift[a] (°F)	2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP and IPLV					
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16
45	75	30	6.71	6.99	7.21	7.55	7.78	7.96
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17
46	80	34	6.33	6.60	6.77	7.02	7.18	7.30
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65
44	85	41	5.47	5.87	6.10	6.33	6.47	6.55
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17
Condenser ΔT[b]			14.04	11.23	9.36	7.02	5.62	4.68

For SI: °C = [(°F) - 32] / 1.8, 1 gallon per minute = 3.785 L/min., 1 ton = 12,000 British thermal units per hour = 3.517 kW.

a. Lift = [Entering condenser water temperature (°F) - Leaving chilled water temperature (°F)].

b. Condenser ΔT = [Leaving condenser water temperature (°F) - Entering condenser water temperature (°F)].

$K_{adj} = 6.1507 - 0.030244(X) + 0.0062692(X)^2 - 0.000045595(X)$

where: X = Condenser ΔT + Lift

$COP_{adj} = K_{adj} \times COP_{std}$

TABLE 803.3.2(6)
PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

EQUIPMENT TYPE	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE[c]
Propeller or axial fan cooling towers	All	95°F entering water 85°F leaving water 75°F wb outdoor air	≥ 38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal fan cooling towers	All	95°F entering water 85°F leaving water 75°F wb outdoor air	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Air cooled condensers	All	125°F condensing temperature R-22 test fluid 190°F entering gas temperature 15°F subcooling 95°F entering db	≥ 176,000 Btu/h · hp (69 COP)	ARI 460

For SI: °C = [(°F) - 32] / 1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon per minute per horsepower = 0.846 L/s · kW, 1-horsepower = 746 W.
wb = wet-bulb temperature, °F

a. For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower units (gpm) divided by the fan nameplate rated motor power units (hp).

b. For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant units (Btu/h) divided by the fan nameplate rated motor power units (hp).

c. Chapter 10 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

803.3.3.4 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 outside air intake or exhaust airflows of 300 cfm (0.14 m^3/s) or less.

803.3.3.5 Economizers. Supply air economizers shall be installed on each cooling system ≥ 65,000 Btu/h. 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.

Exception: Systems using 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.

803.3.3.6 Variable air volume (VAV) fan control. Individual VAV fans with motors of 10 horsepower (7.5 kW) or more shall be:

1. Driven by a mechanical or electrical variable speed drive; or
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 air flow when the static pressure set point equals one-third of the total design static pressure, based on the manufacturer's certified fan data.

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.

803.3.3.7 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 803.3.3.7.1 through 803.3.3.7.3. 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 more than 500,000 Btu/h (148 kW) input design capacity shall include either a multistaged or modulating burner.

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

803.3.3.7.2 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 (Δ8°C) outside air temperatures; be designed to and equipped with controls that will allow operation in one mode for at least 4 hours before changing over to the other mode; and be equipped with controls that allow heating and cooling supply

temperatures at the changeover point to be no more than 30°F (Δ17°C) apart.

803.3.3.7.3 Hydronic (water loop) heat pump systems. 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 maintaining a heat pump water supply temperature dead band of at least 20°F (11°C) between initiation of heat rejection and heat addition by the central devices. If a closed-circuit cooling tower is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower, or lower leakage positive closure dampers shall be installed. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower. If an open-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the cooling tower from the heat pump loop, heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop. 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.

Exception: Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on real time conditions of demand and capacity, dead bands of less than 20°F (Δ11°C) shall be permitted.

803.3.3.7.4 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 controls 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 using adjustable speed drive(s) on pump(s), or multiple-staged pumps where at least one-half of the total pump horsepower can be automatically turned off or control valves designed to modulate or step down, and close, as a function of load, or other approved means.

803.3.3.7.5 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.

803.3.3.8 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 803.3.2(1) through 803.3.2(6).

803.3.4 Requirements for complex mechanical systems serving multiple zones. Sections 803.3.4.1 through 803.3.4.3 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 *International Mechanical Code*.

Exceptions: 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 make VAV systems 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 supplied 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 *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, recool-

ing, 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.

803.3.4.1 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.

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

803.3.4.3 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.

803.3.5 Ventilation. Ventilation shall be in accordance with Section 803.2.5.

803.3.6 Duct and plenum insulation and sealing. All ducts and plenums shall be insulated and sealed in accordance with Section 803.2.8.

Ducts designed to operate at static pressures in excess of 3 inches w.g. (750 Pa) 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 8-2.

$$CL = F \times P^{0.65} \qquad \textbf{(Equation 8-2)}$$

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.

803.3.7 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 803.3.7.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Piping that conveys fluids that have a design operating temperature range between 55°F (13°C) and 105°F (41°C).
3. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
4. Runout piping not exceeding 4 feet (1219 mm) in length and 1 inch (25 mm) in diameter between the control valve and HVAC coil.

803.3.8 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 803.3.8.1 through 803.3.8.3.

803.3.8.1 Air system balancing. 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 25 hp (18.6 kW) and larger.

TABLE 803.3.7
MINIMUM PIPE INSULATION[a]
(thickness in inches)

FLUID	NOMINAL PIPE DIAMETER	
	≤1.5"	> 1.5"
Steam	$1^1/_2$	3
Hot water	1	2
Chilled water, brine or refrigerant	1	$1^1/_2$

For SI: 1 inch = 25.4 mm, 1 British thermal unit per inch/h · ft^2 · °F = 0.144 W/m · K

a. Based on insulation having a conductivity (k) not exceeding 0.27 Btu per inch/h · ft^2 · °F.

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

803.3.8.3 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.

803.3.9 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/h (1758 kW) of heat rejection, and the design service water heating load exceeds 1,000,000 Btu/h (293 kW).

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 use 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 heat 60 percent of their service water from site-solar or site-re- covered energy or from other sources.

803.3.10 Energy recovery ventilation systems. Individual fan systems that have both a design supply air capacity of 5,000 cfm (2.36 m^3/s) or more and a minimum outside air supply of 70 percent or more 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 *International Mechanical Code*.
2. Laboratory fume hood systems with a total exhaust rate of 15,000 cfm (7.08 m^3/s) or less.
3. Laboratory fume hood systems with a total exhaust rate greater than 15,000 cfm (7.08 m^3/s) that include at least one of the following features:
   - 3.1. 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.
   - 3.2 Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (Δ1.1°C) below room set point, cooled to no cooler than 3 °F (Δ1.7°C) above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
4. Systems serving spaces that are not cooled and are heated to less than 60°F (15.5°C).
5. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site-solar energy.
6. Systems requiring dehumidification that use series-style energy recovery coils wrapped around the cooling coil.

SECTION 804
SERVICE WATER HEATING

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

804.1.1 Electrical water heating limitation. Electric service water heating units shall be limited to a maximum of 5 kW total power input.

804.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table 804.2. The efficiency shall be verified through data furnished by the manufacturer or through certification under an approved certification program. Domestic hot water heaters more than 5 kW in total unit input capacity are prohibited.

804.3 Temperature controls. Service-water-heating equipment shall be equipped 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).

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

804.5 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 (0.04 W/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 (0.04 W/m^2 × K).

804.6 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.

804.7 Pools. Pools shall be equipped with energy conserving measures in accordance with Sections 804.7.1 through 804.7.3.

804.7.1 Pool heaters. Pool heaters shall be equipped with a readily accessible on-off switch to allow shutting off the heater without adjusting the thermostat setting. Pool heaters fired by natural gas shall not have continuously burning pilot lights.

804.7.2 Time switches. Time switches that can automatically turn heaters and pumps off and on 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.

TABLE 804.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE
Water heaters, Electric	≤ 5 kW	Resistance	0.97 - 0.00132V, EF	DOE 10 CFR Part 430
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00132V, EF	DOE 10 CFR Part 430
Storage water heaters, Gas	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019V, EF	DOE 10 CFR Part 430
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	$80\%\ E_t$ / $\left(Q/800 + 110\sqrt{V}\right)$SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	$80\%\ E_t$ / $\left(Q/800 + 110\sqrt{V}\right)$ SL, Btu/h	
Instantaneous water heaters, Gas	> 50,000 Btu/h and < 200,000 Btu/h[c]	≥ 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	$80\%\ E_t$ / $\left(Q/800 + 110\sqrt{V}\right)$ SL, Btu/h	
Storage water heaters, Oil	≤ 105,000 Btu/h	≥20 gal	0.59 - 0.0019V, EF	DOE 10 CFR Part 430
	> 105,000 Btu/h	< 4,000 Btu/h/gal	$78\%\ E_t$ / $\left(Q/800 + 110\sqrt{V}\right)$ 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	$78\%\ E_t$ / $\left(Q/800 + 110\sqrt{V}\right)$ 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	≥ 4,000 Btu/h/gal and > 10 gal	$80\%\ E_t$ / $\left(Q/800 + 110\sqrt{V}\right)$ SL, Btu/h	
Hot water supply boilers, Oil	≥ 300,000 Btu/h and <12,500,000 Btu/h	≥ 4,000 Btu/h/gal and > 10 gal	$78\%\ E_t$ / $\left(Q/800 + 110\sqrt{V}\right)$ SL, Btu/h	
Pool heaters, Gas and Oil	All	—	$78\%\ E_t$	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	ARI 1160
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 (h-ft^2-°F)/Btu	(none)

For SI: °C = [(°F) - 32] / 1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

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

b. Standby loss (SL) is the maximum Btu/h based on a nominal 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.

804.7.3 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.

SECTION 805
ELECTRICAL POWER AND LIGHTING SYSTEMS

805.1 General. 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.

Exceptions:

1. Lighting within dwelling units.
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.

805.2 Lighting controls. Lighting systems shall be equipped with controls as required in Sections 805.2.1, 805.2.2 , 805.2.3 and 805.2.4.

805.2.1 Interior lighting controls. Each area enclosed by walls or floor-to-ceiling partitions shall have at least one 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.

805.2.2 Additional controls. Each area that requires a manual control shall have additional controls that meet the requirements of Sections 805.2.2.1 and 805.2.2.2.

805.2.2.1 Light reduction controls. Each area that requires a manual control shall also have means to 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. Guestrooms (see Section 805.2.3).
5. Spaces that use less than 0.6 watt per square foot (6.5 W/m^2).

805.2.2.2 Automatic lighting shutoff. Buildings larger than 5,000 square feet (465 m^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.

Exceptions:

1. Lighting in spaces where patient care is directly provided.
2. Spaces where an automatic shutoff would endanger the safety or security of the room or building occupant(s).
3. Guestrooms (see Section 805.2.3).

805.2.2.2.1 Occupant override. Where an automatic time switch control device is installed to comply with Section 805.2.2.2, 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.
4. Allows the lighting to remain on for no more than 2 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 used, override time may exceed 2 hours.
2. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, the area controlled may not exceed 20,000 square feet (1860 m^2).

805.2.2.2.2 Holiday scheduling. If an automatic time switch control device is installed in accordance with Section 805.2.2.2, 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, churches and theaters.

805.2.3 Guestrooms. Guestrooms 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.

805.2.4 Exterior lighting controls. Lighting for all exterior applications 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 an astronomical time switch. Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. Astronomical 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 adaption.

805.3 Tandem wiring. The following luminaires located within the same area shall be tandem wired:

1. Flourescent luminaires equipped with one, three or other odd-numbered lamp configurations, that are recess-mounted within 10 feet (3048 mm) center-to-center of each other.
2. Flourescent luminaires equipped with one, three or any other 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.

805.4 Exit signs. Internally illuminated exit signs shall not exceed 5 watts per side.

805.5 Interior lighting power requirements. A building complies with this section if its total connected lighting power calculated under Section 805.5.1 is no greater than the interior lighting power calculated under Section 805.5.2.

805.5.1 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 805.5.1.1 through 805.5.1.4.

Exceptions: The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.

1. Specialized medical, dental and research lighting.
2. Professional sports arena playing field lighting.
3. Display lighting for exhibits in galleries, museums and monuments.
4. Guestroom lighting in hotels, motels, boarding houses or similar buildings.
5. Emergency lighting automatically off during normal building operation.

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

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

805.5.1.3 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.

805.5.1.4 Line-voltage lighting track and plug-in busway. The wattage shall be the greater of the wattage of the luminaires determined in accordance with Sections 805.5.1.1 through 805.5.1.3 or 30 W/linear foot (98W/lin m).

805.5.2 Interior lighting power. The interior lighting power shall be calculated using Section 805.5.2.1 or 805.5.2.2 as applicable.

805.5.2.1 Building area method. 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 805.5.2 times the value from Table 805.5.2 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 805.5.2. 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.

805.5.2.2 Space-by-space method. 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 is the floor area for each space-by- space type listed in Table 805.5.3 times the value from Table 805.5.3 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 space-by-space type as listed in Table 805.5.3. When this method is used to calculate the total interior lighting power for an entire building, each space-by-space type shall be treated as a separate area

805.6 Exterior lighting. 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 805.6.1 and 806.6.2.

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

TABLE 805.5.2
INTERIOR LIGHTING POWER ALLOWANCES USING THE BUILDING AREA METHOD

LIGHTING POWER DENSITY	
Building Area Types[a]	**Maximum W/ft^2**
Automotive facility	0.9
Convention center	1.2
Courthouse	1.2
Dining: bar lounge/leisure	1.3
Dining: cafeteria/fast food	1.4
Dining: family	1.6
Dormitory	1.0
Exercise center	1.0
Gymnasium	1.1
Healthcare-clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing facility	1.3
Motel	1.0
Motion picture theater	1.2
Multifamily	0.7
Museum	1.1
Office	1.0
Parking garage	0.3
Penitentiary	1.0
Performing arts theater	1.6
Police/fire station	1.0
Post office	1.1
Religious building	1.3
Retail[b]	1.5
School/university	1.2
Sports arena	1.1
Town hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

For SI: 1 watt per square foot = 10.8 W/m^2.

a. In cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.

TABLE 805.5.3
INTERIOR LIGHTING POWER ALLOWANCES USING THE SPACE-BY-SPACE METHOD

LIGHTING POWER DENSITY	
Common Space Types[a]	LPD (W/ft^2)
Office-enclosed	1.1
Office-open plan	1.1
Conference/meeting/multipurpose	1.3
Classroom/lecture/training	1.4
for penitentiary	1.3
Lobby	1.3
for hotel	1.1
for performing arts theater	3.3
for motion picture theater	1.1
Audience/seating area	0.9
for gymnasium	0.4
for exercise center	0.3
for convention center	0.7
for penitentiary	0.7
for religious buildings	1.7
for sports arena	0.4
for performing arts theater	2.6
for motion picture theater	1.2
for transportation	0.5
Atrium–first three floors	0.6
Atrium–each additional floor	0.2
Lounge/recreation	1.2
for hospital	0.8
Dining area	0.9
for penitentiary	1.3
for hotel	1.3
for motel	1.2
for bar lounge/leisure dining	1.4
for family dining	2.1
Food preparation	1.2
Laboratory	1.4
Restrooms	0.9
Dressing/locker/fitting room	0.6
Corridor/transition	0.5
for hospital	1.0
for manufacturing facility	0.5
Stairs–active	0.6
Active storage	0.8
for hospital	0.9
Inactive storage	0.3
for museum	0.8
Electrical/mechanical	1.5
workshop	1.9

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

Continued

TABLE 805.5.3—Continued
INTERIOR LIGHTING POWER ALLOWANCES USING THE SPACE-BY-SPACE METHOD

LIGHTING POWER DENSITY	
Building Specific Space Types[b]	LPD (W/ft^2)
Gymnasium/exercise center	
playing area	1.4
exercise area	0.9
Courthouse/police station/penitentiary	
courtroom	1.9
confinement cells	0.9
judges chambers	1.3
Fire stations	
fire station engine room	0.8
sleeping quarters	0.3
Post office–sorting area	1.2
Convention center–exhibit space	1.3
Library	
Card file and cataloging	1.1
stacks	1.7
reading area	1.2
Hospital	
emergency	2.7
recovery	0.8
nurse station	1.0
exam/treatment	1.5
pharmacy	1.2
patient room	0.7
operating room	2.2
nursery	0.6
medical supply	1.4
physical therapy	0.9
radiology	0.4
laundry–washing	0.6
Automotive–service/repair	0.7
Manufacturing	
low bay (< 25 ft floor to ceiling height)	1.2
high bay (≥ 25 ft floor to ceiling height)	1.7
detailed manufacturing	2.1
equipment room	1.2
control room	0.5
Hotel/motel guest rooms	1.1
Dormitory–living quarters	1.1
Museum	
general exhibition	1.0
restoration	1.7
Bank/office–banking activity area	1.5

Continued

TABLE 805.5.3—Continued
INTERIOR LIGHTING POWER ALLOWANCES USING THE SPACE-BY-SPACE METHOD

LIGHTING POWER DENSITY	
Building Specific Space Types[b]	**LPD (W/ft^2)**
Religious buildings	
worship pulpit, choir	2.4
fellowship hall	0.9
Retail[c]	
sales area	1.7
mall concourse	1.7
Sports arena	
ring sports area	2.7
court sports area	2.3
indoor playing field area	1.4
Warehouse	
fine material storage	1.4
medium/bulky material storage	0.9
Parking Garage–garage area	0.2
Transportation	
Airport–Concourse	0.6
Air/Train/bus–baggage area	1.0
Terminal–ticket counter	1.5

b. Where installation of lighting equipment for decorative appearances is specified, in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for decorative appearances, or 1.0 W/ft^2 times the area of the space that the decorative lighting equipment is in shall be added to the interior lighting power determined in accordance with this line item.

c. Where installation of lighting equipment to highlight specific merchandise is specified, in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for display, or 1.6 W/ft^2 times the area of the specific display, or 3.9 W/ft^2 times the actual case or shelf area for displaying and selling fine merchandise such as jewelry, fine apparel and accessories, or china and silver, shall be added to the interior lighting power determined in accordance with this line item.

[ANSI/ASHRAE/IESNA Standard 90.1-2004 Energy Standard for Buildings Except Low-Rise Residential Buildings, Section 9, Table 9.6.1,

(Table 9.6.1 has been modified to include footnotes b and c)]

805.6.1 Exterior building grounds lighting. All exterior building grounds luminaires that operate at more 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 805.6.2. Appropriate exterior lighting designs including maximum exterior illuminance levels and cut-off exterior lighting fixtures may be required by the District Environmental Commission for Act 250 projects.

805.6.2 Exterior building lighting power. The total exterior lighting power allowance for all exterior building applications is the sum of the individual lighting power allowances based on the densities permitted in Table 805.6.2 for these applications plus an additional unrestricted allowance of 5 percent of that sum. Trade-offs are allowed only among exterior lighting applications listed in the Table 805.6.2 "Tradable Surfaces" section. Exterior lighting for all applications (except those included in the exceptions to Section 805.6.2) shall comply with the requirements of Section 805.6.1.

Exception: 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.

805.7 Electrical energy consumption. 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.

SECTION 806
OTHER EQUIPMENT

806.1 Motors. All permanently wired electrical motors shall meet the requirements of Section 806.1.1.

806.1.1 Mandatory provisions – Electric motors. Electric motors shall comply with the requirements of the Energy Policy Act of 1992, where applicable, as shown in Table 806.1. Motors that are not included in the scope of the Energy Policy Act have no performance requirements in this section.

806.2 Electric power distribution. Electrical distribution systems shall be designed for the efficient distribution of electrical energy from the service entrance to the point of use.

Exception: Emergency power systems.

806.2.1 Electrical metering. In all multiple-family dwellings, each dwelling unit shall be separately metered.

Exception: Housing for the elderly with fuel heating systems, with centrally operated air conditioning systems, or without air-conditioning systems.

806.2.2 Voltage drop.

802.2.2.1 Feeders. Feeder conductors shall be designed for a maximum voltage drop of 2 percent at full connected load.

806.2.2.2 Branch circuits. Branch circuits conductors shall be designed for a maximum voltage drop of 3 percent at full connected load.

806.3 Transformers. Single-phase and three-phase dry-type and liquid-filled distribution transformers shall be selected based on its rating as described in Section 806.3.1.

Exceptions:

1. Liquid-filled transformers below 10 kVA or dry-type transformers below 15 kVA.
2. All rectifier transformers and transformers designed for high-harmonic autotransformers.
3. Nondistribution transformers such as UPS transformers.
4. Special impedance, regulation and harmonic transformers.
5. Sealed and nonventilated transformers.
6. Retrofit transformers, machine tool transformers or welding transformers.
7. Grounding or testing transformers.
8. Where the loading on the subject transformer can be demonstrated to be such that a different transformer would consume less energy.
9. Dry-type transformers below 15 kVA covered in Item 1 above.
10. Drive transformers, both ac and dc.
11. Transformers with tap ranges greater than 15 percent or frequency other than 60 Hz.

806.3.1 Dry-type transformers. Dry-type transformers shall comply with the minimum efficiencies in Table 806.2 as tested in accordance with NEMA Standard TP-2 1998.

806.3.2 Liquid-filled transformers. Liquid-filled transformers shall comply with the minimum efficiencies in Table 806.3 as tested in accordance with NEMA Standard TP-2 1998.

TABLE 805.6.2
LIGHTING POWER DENSITIES FOR BUILDING EXTERIORS

APPLICATIONS	MAXIMUM 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 watt/linear foot
Walkways 10 feet wide or wider, 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/linear foot of door width
Other doors	20 watts/linear foot of door width
Canopies and Overhangs	
Canopies (free standard, 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/linear foot
Nontradable 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/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

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 10.8 W/m^2.

TABLE 806.1
MINIMUM NOMINAL EFFICIENCY FOR GENERAL PURPOSE MOTORS

NUMBER OF POLES	MINIMUM NOMINAL FULL-LOAD EFFICIENCY (%)					
	Open Motors			Enclosed Motors		
	2	4	6	2	4	6
rpm	3600	1800	1200	3600	1800	1200
Motor Horsepower						
1	—	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	84.0	84.0	85.5	84.0	84.0	86.5
3	84.0	86.5	86.5	85.5	87.5	87.5
5	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	88.5	89.5	90.2	89.5	89.5	89.5
15	89.5	91.0	90.2	90.2	91.0	90.2
20	90.2	91.0	91.0	90.2	91.0	90.2
25	91.2	91.7	91.7	91.0	92.4	91.7
30	91.0	92.4	92.4	91.0	92.4	91.7
40	91.7	93.0	93.0	91.7	93.0	93.0
50	92.4	93.0	93.0	92.4	93.0	93.0
60	93.0	93.6	93.6	93.0	93.6	93.6
75	93.0	94.1	93.6	93.0	94.1	93.6
100	93.0	94.1	94.1	93.6	94.5	94.1
125	93.6	94.5	94.1	94.5	94.5	91.1
150	93.6	95.0	94.5	94.5	95.0	95.0
200	94.5	95.5	94.5	95.0	95.0	95.0

TABLE 806.2
NEMA CLASS 1 EFFICIENCY LEVELS FOR DRY-TYPE DISTRIBUTION TRANSFORMERS

REFERENCE CONDITION		TEMPERATURE (°C)		% OF NAMEPLATE LOAD			
Low Voltage		75		35			
Medium voltage		75		50			
Single-Phase Efficiency				Three-Phase Efficiency			
kVA	Lov Voltage	Medium Voltage ≤ kV BIL > 60 kV BIL		kVA	Low Voltage	Medium Voltage ≤ kV BIL > 60 kV BIL	
15	97.7	97.6	97.6	15	97.0	96.8	96.8
25	98.0	97.9	97.7	30	97.5	97.3	97.3
37.5	98.2	98.1	98.1	45	97.7	97.6	97.6
50	98.3	98.2	98.2	75	98.0	97.9	97.9
75	98.5	98.4	98.4	112.5	98.2	98.1	98.1
100	98.6	98.5	98.5	150	98.3	98.2	98.2
167	98.7	98.8	98.7	225	98.5	98.4	98.4
250	98.8	98.9	98.8	300	98.6	98.6	98.5
333	98.9	99.0	98.9	500	98.7	98.8	98.7
500	—	99.1	99.0	750	98.8	98.9	98.8
667	—	99.2	99.0	1000	98.9	99.0	98.9
883	—	99.2	99.1	1500	—	99.1	99.0
				2000	—	99.2	99.0
				2500	—	99.2	99.1

TABLE 806.3
NEMA CLASS 1 EFFICIENCY LEVELS FOR LIQUID-FILLED DISTRIBUTION TRANSFORMERS

REFERENCE CONDITION	TEMPERATURE (°C)		% OF NAMEPLATE LOAD
Low Voltage	85		50
Medium voltage	20		50
kVA	Single-Phase Efficiency	kVA	Three-Phase Efficiency
10	98.4	15	98.1
15	98.6	30	98.4
25	98.7	45	98.6
37.5	98.8	75	98.7
50	98.9	112.5	98.8
75	99.0	150	98.9
100	99.0	225	99.0
167	99.1	300	99.0
250	99.2	500	99.1
333	99.2	750	99.2
500	99.3	1000	99.2
667	99.4	1500	99.3
883	99.4	2000	99.4
		2500	99.4