780 CMR 13.00

ENERGY CONSERVATION

780 CMR 13.00 is unique to Massachusetts

780 CMR 1301.0 ADMINISTRATION

1301.1 Scope. 780 CMR 13.00 sets forth requirements for the effective use of energy in structures other than *low rise residential buildings*, (low-rise residential structures shall be designed and constructed to comply with the requirements of 780 CMR 61.00 (refer to the 7th Edition *Massachusetts Building Code for One- and Two-Family Dwellings*).

Exception. For the purposes of energy conservation, Use Group R-1 buildings are to be treated as *commercial buildings*.

1301.2 Compliance. Buildings shall be deemed to be in compliance with 780 CMR 13.00 when built to the provisions of 780 CMR 1301.0 and 1303.0, and either:

1. 780 CMR 1303.0 through 1308.0; or
2. 780 CMR 1309.0.

Exception. As an alternative to the provisions of 780 CMR 1304.0, buildings with total floor area not greater than 10,000 square feet may be designed and constructed using the envelope requirements of 780 CMR 61.00 (refer to the 7th Edition *Massachusetts Building Code for One- and Two-Family Dwellings*).

1301.2.1 Heating, Pumping, Process Piping and Refrigeration Systems. Heating, pumping, process piping and refrigeration systems shall be installed by contractors and personnel appropriately licensed in the Commonwealth of Massachusetts (Installing Contractor). Engineered designs and specifications prepared by Registered Professional Engineers shall identify systems requiring compliance with appropriate sections of M.G.L. c. 146 and 528 CMR. Shop drawings and design layout prepared by licensed installing contractors shall note the name(s), license number(s) and license expiration date(s) of the contractor(s) installing the heating, pumping, process piping and refrigeration systems. (See Installing Contractor Definition 780 CMR 202.0).

1301.3 Other Regulations. 780 CMR 13.00 is not intended to abridge any safety or health provisions required under any other applicable codes or ordinances.

1301.4 Existing Buildings. Nothing in 780 CMR 13.00 shall require the removal, alteration, or abandonment, or prevent the continuance of the use and occupancy of, a lawfully existing building, unless provided otherwise specifically by 780 CMR 13.00.

1301.5 Additions to Existing Buildings. Additions to existing buildings or structures shall be made without making the entire building or structure comply. The new construction shall conform to the provisions of 780 CMR 13.00 as they relate to the addition only.

1301.6 Alterations to Existing Buildings. See 780 CMR 3407.0.

1301.7 Exempt Buildings. The following buildings are exempt from the further provisions of 780 CMR 13, with the exception of 780 CMR 1308.0 dealing with lighting requirements:

1. Buildings and structures or portions thereof whose peak design rate of energy usage is less than one watt per square foot or three and four tenths (3.4) Btu/h per square foot of floor area for all purposes;
2. Buildings and structures or portions thereof which are neither heated nor cooled;
3. *Greenhouses* that are free-standing, or attached to a building and separated by a wall having the same thermal value as an exterior wall, and provided with a separate temperature control system;
4. Buildings with less than 100 square feet of gross floor area.
5. Portions of aircraft hangars where aircraft are housed or stored and/or aircraft servicing, repairs or alterations may occur. Such hangars are also exempt from the lighting requirements of 780 CMR 1308.0.

1301.8 Plans and Specifications.

1301.8.1 General. Plans, specifications and necessary computations shall be submitted to indicate conformance with 780 CMR 1301.8 and other applicable sections of 780 CMR. Submittals shall include Mandatory Checklist approved by the Board of Building Regulations and Standards.

1301.8.2 Construction Details. Compliance documents shall show all pertinent data and features of the *building*, *equipment*, and *systems* in sufficient detail to permit a determination of the compliance by the *building* official and to indicate compliance with the requirements of this standard. Supplemental information necessary to verify compliance with this standard, such as calculations, worksheets, compliance forms, vendor literature, or other data, shall be made available when required by the *building official.*

1301.8.3 Calculation Procedures. Calculation procedures shall be in accordance with the

ASHRAE Handbook, 2005 Fundamentals Volume or as otherwise specified in 780 CMR 13.00.

1301.8.4 Approval and Acceptance of Heating, Ventilating, and Air Conditioning (HVAC); Lighting; and Electric Distribution Systems.

1301.8.4.1 Construction Documents. The construction documents shall contain sufficient information to completely describe the heating, ventilation, and air conditioning (HVAC); lighting; and electric power distribution systems, including operational features and controls. The information required for each system shall include a summary of:

1. A description of the design intent providing a detailed explanation of the ideas, concepts and criteria that are defined by the owner to be important.
2. A description of the basis of design of the systems including all information necessary to prepare a design to accomplish the design intent.
3. A description of the sequence of operation of the systems and their interaction with other systems, including fire prevention and fire protection systems.
4. A description of the systems including the capacities of the equipment or systems.
5. A description of the testing requirements and the criteria for passing to be used for final systems acceptance.
6. A requirement for submittal of operation manuals and maintenance manuals as a condition of final acceptance, and a description of their format and content. The operation manual shall provide all relevant information needed for day-to-day operation and management of each system. The maintenance manual shall describe equipment inventory and support the maintenance program.
7. A requirement for submittal of record drawings and control documents as a condition of final acceptance, per 780 CMR 116.0.

1301.8.4.2 Approval. Approval by the building official of the design concepts, testing procedures, and acceptance criteria of 780 CMR 1301.8.4.1, 1. through 7., is not required, but the building official shall reject the construction documents if these sections are incomplete, or if they specify any design elements that violate other requirements of 780 CMR.

1301.8.4.3 Design. All HVAC, lighting, and electric power distribution systems including sequence of operation, controls and supporting documentation shall be designed and specified by a qualified Registered Professional Engineer except as provided in M.G.L. c. 143, § 54A and any profession or trade as provided in M.G.L. c. 112, § 60L and M.G.L. c. 112, § 81R. The Registered Professional Engineer(s) or other legally recognized professional (M.G.L. c. 112, § 81R) shall be responsible for the review and certification that all submittals and shop drawings conform to the approved HVAC, lighting, and electric power distribution construction documents as submitted for the building permit and approved by the building official, per 780 CMR 116.0.

1301.8.4.4 Acceptance. In accordance with the provisions of 780 CMR 120.0, a certificate of occupancy shall not be issued until the building official or his designees have witnessed a satisfactory test of all HVAC, lighting control, and electric power distribution systems installed in accordance with the construction documents. All systems shall be tested in accordance with the applicable standards of 780 CMR and documents. In addition, the following documents shall be simultaneously submitted to the building official prior to the issuance of a permanent certificate of occupancy.

1. Certification from the Registered Professional, as allowed in 780 CMR 116.2, stating that the HVAC, lighting, and electric power distribution systems have been installed in substantial accord with the approved construction documents.
2. Confirmation by the building owner/ developer or authorized representative that they have received all HVAC, lighting, and electric power distribution system record drawings from the installing contractors and that the Registered Professional Engineer or other legally recognized professional (M.G.L. c. 112, § 81R) has reviewed their reasonable accuracy.
3. Confirmation by the building owner/ developer or authorized representative that they have received all construction documents required in 780 CMR 1301.8.4.1 including reports, controls documentation, operation manual(s) and maintenance manual(s).

Exception. In lieu of witnessing a satisfactory functional test, the building official or their designees may accept a final performance acceptance test report from a Registered Professional Engineer or other legally recognized professional (M.G.L. c. 112, § 81R). Said report shall certify that the systems have been tested and satisfactorily meet their performance requirements.

1301.8.4.5 Unsafe Lighting and Ventilation. The *building official* may require or accept the documentation required in 780 CMR

1301.8.4.4 in enforcing the provisions of 780 CMR 3400.6.

1301.8.4.6 Conditional Acceptance. The requirements of 780 CMR 1301.8.4.4 shall not preclude the issuance of a temporary certificate of occupancy by the Building Official in accordance with 780 CMR 120.3 as long as it can be demonstrated that compliance can be accomplished with the building occupied.

1301.9 Materials and Equipment.

1301.9.1 Identification. Where practicable, all materials and equipment referenced in 780 CMR 1301.8 shall be marked in order to show compliance with 780 CMR 13.00.

1301.9.2 Maintenance Information. Service systems which require preventive maintenance to maintain efficient operation shall be furnished with complete necessary maintenance information. Required routine maintenance actions, as specified by the manufacturer, shall be stated clearly and incorporated on a readily accessible label on the equipment. Such label may be limited to identifying, by title or publication number, the operation and maintenance manual for that particular model and type of product.

1301.9.3 Fenestration and Doors. Product samples used for determining *fenestration* performance shall be production line units or representative of units as purchased by the consumer or contractor.

1301.9.3.1 U-Factor. *U-factors* shall be determined in accordance with AAMA 1503 or NFRC 100. *U-factors* for *skylights* shall be determined in accordance with NFRC 100. *U-factor* shall be determined by an independent laboratory accredited by a nationally recognized accreditation organization and shall be certified by the manufacturer.

Exceptions:

1. If a manufacturer of windows, window systems, skylights, glazed or unglazed door has not determined product U-value in accordance with 780 CMR 1301.9.3.1, compliance with the requirements of 780 CMR 13.00 shall be determined only by assigning such products a default U-value in accordance with Table 1301.9.3.1a or 1301.9.3.1b. Product features must be verifiable for the product to qualify for the default value associated with those features. Where existence of a particular feature cannot be determined with reasonable certainty, the product shall not receive credit for that feature. Where a composite of materials from two different product types is used, the product shall be assigned the higher U-value.
2. For garage doors, ANSI/DASMA 105 shall be an acceptable alternate for determining U Factor.

TABLE 1301.9.3.1a U-VALUE DEFAULT TABLE FOR WINDOWS, CURTAIN WALLS, AND SKYLIGHTS[a]

Frame Material and Product Type[b]	Single Glazed	Double Glazed	Double Glazed Low-e[c]	Triple Glazed	Triple Glazed Low-e[c]
Metal without Thermal Break					
Windows	1.27	0.87	0.79	0.72	0.69
Curtain Walls	1.22	0.79	0.70	0.63	0.59
Skylight	1.98	1.31	1.20	1.12	1.08
Site-assembled sloped/overhead glazing	1.36	0.82	0.71	0.64	0.60
Metal with Thermal Break					
Windows	1.07	0.63	0.54	0.48	0.44
Curtain Walls	1.61	0.68	0.59	0.52	0.48
Skylight	1.89	1.61	1.00	0.89	0.85
Site-assembled sloped/overhead glazing	1.25	0.70	0.60	0.53	0.49
Wood/Vinyl/Fiberglass					
Windows	0.98	0.56	0.48	0.41	0.37
Skylight	1.75	0.84	0.74	0.64	0.59

a. Certain values in this table do not meet the limits of **780 CMR 1304.2, Prescriptive Building Envelope Criteria**, or **780 CMR 1305, Building Envelope Trade-Off Option**, and may be used only when demonstrating compliance using **780 CMR 1309, Building Design by Systems Analysis**.
b. Glass block assemblies with mortar but without reinforcing or framing shall have a default value of 0.60.
c. Presence of low-e coating must be certified in writing by the manufacturer.

TABLE 1301.9.3.1b U-VALUE DEFAULT TABLE FOR DOORS

Door Type	
Opaque	0.70
Glass	0.92
Air Lock Entry	0.50
Revolving	0.50
Overhead	1.45

1301.9.3.2 Solar Heat Gain Coefficient. *Solar heat gain coefficient (SHGC)* for the overall *fenestration area* shall be determined in accordance with NFRC 200. *Solar heat gain coefficient* shall be determined by an independent laboratory accredited by a nationally recognized accreditation organization and shall be certified by the manufacturer.

Exception. If a manufacturer of windows, window systems, skylights, glazed or unglazed door has not determined product Solar Heat Gain Coefficient in accordance with 780 CMR 1301.9.3.2, compliance with the requirements of 780 CMR 13.00 shall be determined only by assigning such products a default SHGC in accordance with Table 1301.9.3.2. Credit for low-e coating may be taken only if presence of such coating is certified in writing by the manufacturer.

1301.9.3.3 Visible Light Transmittance. When 780 CMR 1304.5 is used with daylighting credit, visible light transmittance shall be determined in accordance with NFRC 200. Visible light transmittance shall be determined by an independent laboratory accredited by a nationally recognized accreditation organization and shall be certified by the manufacturer.

Exception. If a manufacturer of windows, window systems, skylights, glazed or unglazed door has not determined product Visible Light Transmittance in accordance with 780 CMR 1301.9.3.3, compliance with the requirements of 780 CMR 13.00 shall be determined only by assigning such products a default VLT in accordance with Table 1301.9.3.2. Credit for low-e coating may be taken only if presence of such coating is certified in writing by the manufacturer.

TABLE 1301.9.3.2 SHGC AND VLT DEFAULT TABLE FOR FENESTRATION[a]

Glass Type	Metal Frame		Non-Metal Frame	
	SHGC	VLT	SHGC	VLT
Single Glazed				
Clear	0.78	0.80	0.76	0.78
Tinted	0.67	0.61	0.65	0.59
Reflective	0.53	0.37	0.52	0.36
Double Glazed				
Clear	0.68	0.72	0.66	0.70
Tinted	0.57	0.55	0.56	0.54
Reflective	0.46	0.32	0.45	0.31
Double Glazed Low-e				
Clear	0.64	0.68	0.63	0.66
Tinted	0.59	0.50	0.58	0.49
Reflective	0.46	0.32	0.45	0.31
Triple Glazed				
Clear	0.61	0.66	0.60	0.64
Tinted	0.42	0.22	0.41	0.22
Reflective	0.36	0.25	0.35	0.25
Triple Glazed Low-e				
Clear	0.57	0.61	0.56	0.59
Tinted	0.42	0.33	0.41	0.32
Reflective	0.36	0.25	0.35	0.25

a Presence of low-e coating must be certified in writing by the manufacturer.

780 CMR 1302.0 DEFINITIONS

1302.1 Meaning. Unless otherwise expressly stated, the following terms shall, for the purpose of 780 CMR 13.00, have the meaning indicated in 780CMR 1302.0.

1302.2 Tense, Gender and Number. Words used in the present tense include the future; words used in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural the singular.

1302.3 Terms Not Defined. Where terms are not defined, they shall have their ordinarily accepted meanings or such as the context may imply. Any terms relating to plumbing and electrical wiring shall have their terms as defined by the Regulations of the Commonwealth of Massachusetts pertaining to plumbing and electrical wiring.

Accessible (As Applied to Equipment). Admitting close approach because not guarded by locked doors, elevation or other effective means (see "Readily accessible").

Air Conditioning, Comfort. The process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution to meet requirements of the conditioned space.

Air Transport Factor. The ratio of the rate of useful sensible heat removal from the conditioned space to the energy input to the supply and return fan motor(s), expressed in consistent units and under the designated operating conditions.

Automatic. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature or mechanical configuration (see "Manual").

Ballast. A device used in conjunction with an electric-discharge lamp to cause the lamp to start and operate under the proper circuit conditions of voltage, current, wave form, electrode heat, etc.

Electronic Ballast. A ballast constructed using electronic circuitry.

Hybrid Ballast. A ballast constructed using a combination of magnetic core and insulated wire winding and electronic circuitry.

Magnetic Ballast. A ballast constructed with magnetic core and a winding of insulated wire.

Below-grade Wall. The opaque portion of a wall which encloses one side of a basement and is partially or totally below grade.

Boiler. An appliance designed to heat water or generate steam (see "Packaged boiler".)

Building Area. The greatest horizontal area of a building above grade within the outside surface of exterior walls or within the outside surface of exterior wall and the center line of fire walls.

Building Envelope. The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from unconditioned spaces or other spaces exempted by the provisions of 780 CMR 1301.7.

Building Entrance. Any doorway, set of doors, turnstiles, or other form of portal that is ordinarily used to gain access to the building by its users and occupants.

Building Grounds Lighting. Lighting provided through a building's electrical service for parking lot, site, roadway, pedestrian pathway, loading dock, and security applications.

Building Project. A building or group of buildings, including on-site energy conversion or electric-generating facilities, which utilize a single submittal for a construction permit or are within the boundary of a contiguous area under one ownership.

Coefficient of Performance (COP) - Heat Pump - Heating. The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system under designated operating conditions.

Comfort. The physical conditions represented in the area on a psychometric chart enclosing all those conditions described in Figure 1 in ASHRAE 55, as listed in 780 CMR 35.00, as being comfortable.

Commercial Building. For purposes of energy conservation, a commercial building is any building other than a low-rise residential building, as defined in 780 CMR J2.0.

Conditioned Floor Area. The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

Conditioned Space. Space within a building which is provided with positive heat supply (see definition), or which has heated and/or cooled air or surfaces, or where required, with humidification or dehumidification means so as to be capable of maintaining a space condition falling within the comfort zone set forth in ASHRAE 55, as listed in 780 CMR 35.00.

Continuous Air Barrier. the combination of interconnected materials and assemblies, joined and sealed together with flexible joints that provide the air-tightness of the building envelope above and below grade that separate conditioned from unconditioned space, or from space with conditions that differ by more than 50% .

Continuous Insulation (ci). Insulation that is continuous across all structural members without any thermal bridges, excluding fasteners and service openings. It is installed on the interior, exterior, or

integral to any opaque surface of the building envelope.

Control Device. A specialized device used to regulate the operation of equipment.

Dead band. The temperature range in which no heating or cooling is used.

Degree Day, Cooling (CDD). A unit, based upon temperature difference and time, used in estimating cooling energy consumption. For any one day, when the mean temperature is more than 65°F., there are as many degree days as degrees Fahrenheit temperature difference between the mean temperature for the day and 65°F. Annual Cooling Degree Days (CDD) are the sum of the degree days over a calendar year.

Degree Day, Heating (HDD). A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load of a building in winter. For any one day, when the mean temperature is less than 50°F., there exists as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 50°F. Annual Heating Degree Days (HDD) are the sum of the degree days over a calendar year.

Design Conditions. Specified environmental conditions, such as temperature and light intensity, required to be produced and maintained by a system and under which the system must operate.

Direct Digital Control (DDC). A type of control where controlled and monitored analog or binary data (e.g., temperature, contact closures) are converted to digital format for manipulation and calculations by a digital computer or microprocessor, then converted back to analog or binary form to control physical devices.

Distribution System. Conveying means, such as ducts, pipes, and wires, to bring substances or energy from a source to the point of use. The distribution system includes such auxiliary equipment as fans, pumps, and transformers.

Door. All operable opening areas (which are not fenestration) in the building envelope, including swinging and roll-up doors, fire doors, and access hatches. Doors that are more than one-half glass are considered fenestration. (See Fenestration.) For the purposes of determining building envelope requirements, the classifications are defined as follows:

Non-swinging. Roll-up, sliding, and all other doors that are not swinging doors.

Swinging. All operable opaque panels with hinges on one side and opaque revolving doors.

Door Aea. Total area of the door measured using the rough opening and including the door slab and the frame. (See "Fenestration area.")

Economizer, air. A duct and damper arrangement and automatic control system that together allows a cooling system to supply outside air to reduce or eliminate the need for mechanical cooling during mild or cold weather.

Economizer, water. A system by which the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling.

Efficiency. Performance at specified rating conditions.

Efficiency, HVAC System. The ratio of useful energy output (at the point of use) to the energy input in consistent units for a designated time period, expressed in percent.

Emergency Power System. A system that operates in the event of primary system failure or provides power to essential loads during power supply outages.

Enclosed Space. A volume substantially surrounded by solid surfaces such as walls, floors, roofs, and openable devices such as doors and operable windows.

Enclosure. The case or housing of an apparatus, or the fence or walls surrounding an installation, to prevent personnel from accidentally contacting energized parts or protect equipment from physical damage.

Energy. The capacity for doing work taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical in customary units, measured in kilowatt-hours (kWh) or British thermal units (Btu) (J) (see “New Energy”).

New Energy. Energy, other than recovered energy, utilized for the purpose of heating or cooling (see “Energy”).

Energy Efficiency Ratio (EER). The ratio of net equipment cooling capacity in Btu/h to total rate of electric input in watts (W) under designated operating conditions. If the output capacity in Btu/h is converted to watts (to create consistent units) the result is equal to the cooling COP (EER 3.41 = COP). See also Coefficient of Performance.

Energy, Recovered. (See "Recovered energy.")

Exfiltration. The uncontrolled outward air leakage through cracks and interstices in any building element and around windows and doors of a building caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

Existing Buildings. For purposes of energy conservation, and existing building which has been

legally occupied and/or used for a period of at least five years. (Also see 780 CMR 2.00 and 780 CMR 3400.3.1.)

Exterior Lighting Power Allowance. (See "Lighting power allowance.")

Façade Area, Vertical. Area of the façade, including non-horizontal roof area, overhangs, and cornices, measured in elevation in a vertical plane parallel to the plane of the face of the building.

F-factor. The perimeter heat loss factor for slab-on-grade floors, expressed in Btu/h*ft*°F.

Fan System Energy Demand (Or Fan System Power). The sum of the nominal power demand (nameplate horsepower) of motors of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the conditioned space(s) and return it to the source or exhaust it to the outdoors.

Fenestration. All areas (including the frames) in the building envelope that let in light, including windows, plastic panels, clerestories, skylights, glass doors that are more than one-half glass, and glass block walls. (See Building envelope and Door.)

Skylight. A fenestration surface having a slope of less than 60° from the horizontal plane. Other fenestration, even if mounted on the roof of a building, is considered vertical fenestration.

Vertical fenestration. All fenestration other than skylights.

Fenestration Area. Total area of the fenestration measured using the rough opening and including the glazing, sash, and frame. For doors where the glazed vision area is less than 50% of the door area, the fenestration area is the glazed vision area. For all other doors, the fenestration area is the door area. (See "Door area.")

Fenestration, Vertical. (See "Fenestration" and "Skylight.")

Fixture. The component of a luminaire that houses the lamp or lamps, positions the lamp, shields it from view, and distributes the light. The fixture also provides for connection to the power supply, which may require the use of a ballast.

Floor. That lower portion of the building envelope, including opaque area and fenestration, that has conditioned or semiheated space above and is horizontal or tilted at an angle of less than 60 degrees from horizontal but excluding slab-on-grade floors. For the purposes of determining building envelope requirements, the classifications are defined as follows:

Mass Floor. A floor with a heat capacity that exceeds:

1. 7 Btu/ft2*°F or
2. 5 Btu/ft2*°F provided that the floor has a material unit weight not greater than 120 lb/ft^3.

Steel Joist Floor. A floor that:

1. is not a mass floor and
2. which has steel joist members supported by structural members.

Wood Framed and Other Floors. All other floor types, including wood joist floors.

(See "Building envelope", "Fenestration", "Opaque area", and "Slab-on-grade floor.")

Floor Area, Gross. The sum of the floor areas of the spaces within the building including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 7.5 ft (2.3 m) or greater. It is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features.

Gross Building Envelope Floor Area. The gross floor area of the building envelope, but excluding slab-on-grade floors.

Gross Conditioned Floor Area. The gross floor area of conditioned spaces.

Gross Lighted Floor Area. The gross floor area of lighted spaces.

Gross Semiheated Floor Area. The gross floor area of semiheated spaces.

(See "Building envelope", "Floor", "Slab-on-grade floor," and "Space.")

Flue Damper. A device in the flue outlet or in the inlet of or upstream of the draft control device of an individual, automatically operated, fossil fuel-fired appliance that is designed to automatically open the flue outlet during appliance operation and to automatically close the flue outlet when the appliance is in a standby condition.

Footcandle (fc). The illuminance on a surface one ft^2 in area on which there is a uniformly distributed flux of one lumen, or the illuminance produced on a surface all points of which are at a distance of one foot from a directionally uniform point source of one candle. (For SI users, one footcandle equals 10.76 lux.)

Fossil Fuel. An organic material, other than wood, used as a fuel.

Furnace, Duct. A furnace normally installed in distribution ducts of air conditioning systems to supply warm air for heating and which depends on a blower not furnished as part of the duct furnace for air circulation.

Furnace, Warm Air. A self-contained, indirect-fired or electrically heated furnace that supplies heated air through ducts to spaces that require it.

Glazed Wall System. A category of site assembled fenestration products used in the NFRC 100 and NFRC 200 rating procedures which includes, but is not limited to, curtain walls and solariums.

Grade. The finished ground level adjoining a building at all exterior walls.

Glazing Area. Interior surface area of all glazed surfaces (such as windows, sliding glass doors, skylights, etc.), sash, curbing, jambs, or other framing elements that enclose conditioned spaces.

Gross Area of Exterior Walls. The normal projection of the building envelope wall area bounding interior space which is conditioned by an energy-using system including opaque wall, window and door area.

The gross area of exterior walls consists of all opaque wall areas, including between floor spandrels, peripheral edges of floors, roof and basement knee walls, walls enclosing a mansard roof, window areas including sash, and door areas when such surfaces are exposed to outdoor air, unconditioned spaces, or mechanically cooled space, including interstitial areas between two such spaces. For each basement wall that encloses heated space, if the average below-grade area is less than 50% of the total area for that wall, including openings, the entire wall, including the below-grade portion is included as part of the gross area of exterior walls. Non-opaque areas (windows, doors, etc.) of all basement walls are included in the gross area of exterior walls. (Note. if the basement is not heated space, and if the basement ceiling is insulated, then the basement walls are not included in the gross area of exterior walls.

Gross Floor Area. The sum of the areas of the several floors of the building, including basements, cellars, mezzanine and intermediate floored tiers and penthouses of headroom height, measured from the exterior faces of exterior walls or from the center line of walls separating buildings, but excluding:

1. covered walkways, open roofed-over areas, porches and similar spaces.
2. pipe trenches, exterior terraces or steps, chimneys, roof overhangs and similar features.

Heat. The form of energy that is transferred by virtue of a temperature difference or a change in state of a material.

Heated Space. Space within a building which is provided with a positive heat supply. Space within a basement with registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space.

Humidistat. An automatic control device used to maintain humidity at a fixed or adjustable set point.

HVAC. Heating, ventilating, and air conditioning.

HVAC System. The equipment, distribution network, and terminals that provide either collectively or individually the processes of heating, ventilating, or air conditioning to a building.

HVAC System Components. HVAC system components provide, in one or more factory-assembled packages, means for chilling and/or heating water with controlled temperature for delivery to terminal units serving the conditioned spaces of the building. Types of HVAC system components include, but are not limited to, water chiller packages, reciprocating condensing units and water source (hydronic) heat pumps (See "HVAC system equipment").

HVAC System Efficiency. (See "Efficiency, HVAC system.")

HVAC System Equipment. HVAC system equipment provides, in one (single package) or more (split system) factory-assembled packages, means for air circulation, air cleaning, air cooling with controlled temperature and dehumidification, and, optionally, either alone or in combination with a heating plant, the functions of heating and humidifying. The cooling function may be either electrically or heat operated and the refrigerant condenser may be air, water or evaporatively cooled. Where the equipment is provided in more than one package, the separate packages shall by designed by the manufacturer to be used together. The equipment may provide the heating function as a heat pump or by the use of electric or fossil-fuel-fired elements. (The word "equipment" used without modifying adjective may, in accordance with common industry usage, apply either to HVAC system equipment or HVAC system components.)

Indirectly Conditioned Space. (See "Space.")

Infiltration. The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

Installed Interior Lighting Power. The power in watts of all permanently-installed general, task, and furniture lighting systems and luminaires as indicated on plans and specifications.

Integrated Part-load Value (IPLV). A single number figure of merit based on part-load EER or COP expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

Interior Lighting Power Allowance. (See "Lighting power allowance.")

Isolation Devices. Devices that isolate HVAC zones so that they can be operated independently of

one another. Isolation devices include, but are not limited to, separate systems, isolation dampers, and controls providing shutoff at terminal boxes.

Lighting Power Allowance.

Interior Lighting Power Allowance. The maximum lighting power in watts allowed for the interior of a building.

Exterior Lighting Power Allowance. The maximum lighting power in watts allowed for the exterior of a building.

Lighting Power Density (LPD). The maximum lighting power per unit area of a building classification of space function.

Low-rise Residential Buildings. Residential occupancy buildings (R-2, R-3, R-4, or R-5) three stories or less in height. (Exception. For purposes of energy conservation, R-1 use group buildings shall be treated as commercial buildings as defined in 780 CMR J2.0.)

Lumen (lm). The luminous flux emitted within a unit solid angle (one steradian) by a point source having a uniform luminous intensity of 1 cd.

Luminaire. A complete lighting unit consisting of a lamp or lamps together with the housing designed to distribute the light, position and protect the lamps, and connect the lamps to the power supply.

Manufacturer. The company engaged in the original production and assembly of products or equipment or a company that purchases such products and equipment manufactured in accordance with company specifications.

Manual. Capable of being operated by personal intervention (See "Automatic.")

Multi-family Dwelling. A building containing three or more dwelling units.

Net Area of Exterior Walls. The gross area of exterior walls, minus the total rough opening area of all windows and doors set in the exterior walls.

Nondepletable Energy Sources. Sources of energy (excluding minerals and solid fuels) derived from incoming solar radiation, including natural daylighting and photosynthetic processes; from phenomena resulting there from, including wind, waves and tides, lake or pond thermal differences; and from the internal heat of the earth, including nocturnal thermal exchanges.

Nonrecirculating System. A domestic or service hot water distribution system that is not a recirculating system.

Occupant Sensor. A device that detects the presence or absence of people within an area and causes lighting, equipment, or appliances to be regulated accordingly.

Opaque Areas. All exposed areas of a building envelope which enclose conditioned space, except openings for windows, skylights, doors and building service systems.

Outdoor Air. Air taken from the outdoors and therefore not previously circulated through the system.)

Packaged Boiler. A boiler that is shipped complete with heating equipment, mechanical draft equipment, and automatic controls; usually shipped in one or more sections.

Plenum. An enclosure that is part of the air distribution system and is distinguished by having almost uniform air pressure. A plenum often is formed in part or in total by portions of the building.

Pool. A body of non-potable water contained in a human-made structure intended and large enough for substantial immersion of one or more people. The term includes but is not limited to swimming pool, whirlpool, spa, and hot tub.

Positive Heat Supply. Heat deliberately supplied to a space by design, such as a supply register, radiator or heating element. Also, heat indirectly supplied to a space through uninsulated surfaces of service water heaters and space heating components, such as furnaces, boilers and heating and cooling distribution systems which continually maintain air temperature within the space of 50°F. or higher during normal operation.

Projection Factor (PF). The ratio of the horizontal depth of the external shading projection divided by the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the farthest point of the external shading projection, in consistent units.

Proposed Design. A description of the proposed building design used to estimate annual energy costs for determining compliance based on 780 CMR 1309.0.

Rated R-value of Insulation. The thermal resistance of the insulation alone as specified by the manufacturer according to recognized trade and engineering standards in units of h*ft2*°F/Btu at a mean temperature of 75°F. Rated R-value refers to the thermal resistance of the added insulation in framing cavities or insulated sheathing only and does not include the thermal resistance of other building materials or air films. (See "Thermal resistance.")

Readily Accessible. Capable of being reached quickly for operation, renewal or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders or access equipment (see "Accessible.")

Recooling. The removal of heat by sensible cooling of the supply air (directly or indirectly) that has been

previously heated above the temperature to which the air is to be supplied to the conditioned space for proper control of the temperature of that space.

Record Drawings. Drawings that record the conditions of the project as constructed. These include any refinements of the construction or bid documents.

Recovered Energy. Energy utilized which would otherwise be wasted (i.e., not contribute to a desired end use) from an energy utilization system.

Reheat. The application of sensible heat to supply air that has been previously cooled below the temperature of the conditioned space by either mechanical refrigeration or the introduction of outdoor air to provide cooling.

Reset. Adjustment of the set point of a control instrument to a higher or lower value automatically or manually to conserve energy.

Roof Assembly. A roof assembly shall be considered as all components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to outdoor air and encloses a heated or mechanically cooled space.

The gross area of a roof assembly consists of the total interior surface of such assembly, including skylights exposed to the heated or mechanically cooled space.

Sequence. A consecutive series of operations.

Service Systems. All energy-using systems in a building that are operated to provide services for the occupants or processes housed therein, including HVAC, service water heating, illumination, transportation, cooking or food preparation, laundering and similar functions.

Service Water Heating. Supply of hot water for purposes other than space heating.

Setback. Reduction of heating (by reducing the set point) or cooling (by increasing the setpoint) during hours when a building is unoccupied or during periods when lesser demand is acceptable.

Slab-on-grade. A floor slab for which the top edge of the perimeter is above the finished grade or 12 inches or less below the finished grade.

Solar Energy Source. Source of natural daylighting and of thermal, chemical or electrical energy derived directly from conversion of incident solar radiation.

Solar Heat Gain Coefficient (SHGC). The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space. (See fenestration area.)

Standard Design. A version of the proposed design that meets the minimum requirements of 780 CMR 1300 and is used to determine the annual energy usage for determining compliance based on 780 CMR 1309.0.

System. A combination of central or terminal equipment or components and/or controls, accessories, interconnecting means, and terminal devices by which energy is transformed so as to perform a specific function, such as HVAC, service water heating or illumination.

Thermal Conductance (C). Time rate of heat flow through a body (frequently per unit area) from one of its bounding surfaces to the other for a unit temperature difference between the two surfaces, under steady conditions (Btu/h*ft*2*°F.).

Thermal Resistance (R). The reciprocal of thermal conductance (h*ft*2*°F/Btu).

Thermal Resistance, Overall (Ro). The reciprocal of overall thermal conductance (h*ft*2*°F /Btu) [(m2.k)/W]. The overall thermal resistance of the gross area or individual component of the exterior building envelope (roof/ceiling, exterior wall, floor, crawl space wall, foundation, window, skylight, door, or opaque wall, etc.) which includes the weighted R-values of the component assemblies (such as air-film, insulation, drywall, framing, glazing, etc.).

Thermal Transmittance (U). The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/ h*ft*2*°F.) The U-value applies to combinations of different materials used in series along the heat flow path, single materials that comprise a building section, cavity air spaces and surface air films on both sides of a building element. The term F-value applies to U properties for concrete slabs.

Thermal Transmittance, Overall (Uo). The overall (average) heat transmission of a gross area of the exterior building envelope (Btu/ h*ft*2*°F.) The Uo value applies to the combined effect of the time rate of heat flow through the various parallel paths, such as windows, doors and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/ceilings.

Thermostat. An automatic control device actuated by temperature and designed to be responsive to temperature.

Thermostatic Control. An automatic control device or system used to maintain temperature at a fixed or adjustable set point.

Transformer. A piece of electrical equipment used to convert electric power from one voltage to another voltage.

Dry-type Transformer. A transformer in which the core and coils are in a gaseous or dry compound.

Liquid-immersed Transformer. A transformer in which the core and coils are immersed in an insulating liquid.

Unitary Cooling and Heating Equipment. One or more factory-made assemblies which include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well. When heating and cooling equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

Unitary Heat Pump. One or more factory-made assemblies which include an indoor conditioning coil, compressor(s) and outdoor coil or refrigerant-to-water heat exchanger, including means to provide both heating and cooling functions. When heat pump equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

Variable Air Volume (VAV) System. HVAC system that controls the dry-bulb temperature within a space by varying the volumetric flow of heated or cooled supply air to the space.

Vent Damper. A device intended for installation in the venting system of an individual, automatically-operated, fossil fuel fired appliance in the outlet or downstream of the appliance draft control device which is designed to automatically open the venting system when the appliance is in operation and to automatically close off the venting system when the appliance is in a standby or shutdown condition.

Ventilation. The process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned.

Ventilation Air. That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. (See BOCA Mechanical Code, as listed in 780 CMR 35.00, 78 CMR J3, and definition of "Outdoor air.")

Voltage Drop. A decrease in voltage caused by losses in the lines connecting the power source to the load.

Wall. That portion of the building envelope, including opaque area and fenestration, that is vertical or tilted at an angle of 60° from horizontal or greater. This includes above- and below-grade walls, between floor spandrels, peripheral edges of floors, and foundation walls. For the purposes of determining building envelope requirements, the classifications are defined as follows:

Above-grade Wall. A wall that is not a below-grade wall.

Below-grade Wall. That portion of a wall in the building envelope that is entirely below the finish grade and in contact with the ground.

Metal Building Wall. a wall whose structure consists of metal spanning members supported by steel structural members (i.e., does not include spandrel glass or metal panels in curtain wall systems).

Steel Framed Wall. A wall with a cavity (insulated or otherwise) whose exterior surfaces are separated by steel framing members (i.e., typical steel stud walls and curtain wall systems).

Wood Framed and Other Walls. All other wall types, including wood stud walls.

Wall Area, Gross. The area of the wall measured on the exterior face from the top of the floor to the bottom of the roof.

Water Heater. Closed vessel in which water is heated by the combustion of fuels, electricity, or any other source and is withdrawn for use external to the system at pressures not exceeding 160 psig, including the apparatus by which heat is generated and all controls and devices necessary to prevent water temperatures from exceeding 210°F.

Zone. A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

780 CMR 1303.0 DESIGN CONDITIONS

1303.1 Scope. 780 CMR 1303.0 applies to all buildings.

1303.2 General. The criteria of 780 CMR 1303.0 establish the minimum requirements for the thermal design of the exterior envelope of buildings and for HVAC systems and equipment.

1303.3 Design Parameters. The design parameters listed in Tables 1303.1 and 1303.2 shall be used for calculations required under 780 CMR 13.00.

1303.3.1 Interior Design Conditions. Indoor design temperature and relative humidity shall be determined in accordance with ASHRAE Standard 55-92 listed in 780 CMR 35.00, and shall be selected for minimum total HVAC system energy use in accordance with accepted practice.

Exception. Buildings or portions of buildings which require different temperatures and humidity, such as, but not limited to, hospitals, laboratories, museums, art galleries, super-markets, thermally sensitive equipment rooms, archival storage facilities, and facilities for the elderly, may require the use of alternative

indoor design conditions. Any such use of alternative indoor design conditions shall be documented by a licensed professional.

1303.4 Ventilation. Ventilation air shall conform to the requirements specified in 780 CMR 2801.0.

TABLE 1303.1 CLIMATE ZONE BY COUNTY

County	Climate Zone #
Barnstable	12a
Berkshire	14a
Bristol	12a
Dukes	12a
Essex	13a
Franklin	14a
Hampden	14a
Hampshire	14a
Middlesex	13a
Nantucket	12a
Norfolk	13a
Plymouth	12a
Suffolk	13a
Worcester	14a

TABLE 1303.2 CLIMATE ZONE THERMAL DESIGN CRITERIA

Climate Zone #	12a	13a	14a
Heating Degrees (°F) Winter	9	7	-1
Cooling Degrees (°F) Dry Bulb Summer	86	87	86
Cooling Degrees (°F) Wet Bulb Summer	74	74	73
Heating Degree Days Base 65	5884	5641	6894
Heating Degree Days Base 50	2553	2399	3448
Cooling Degree Days Base 65	606	678	507
Cooling Degree Days Base 50	2743	2897	2525
Cooling Degree Hours Base 80	939	1299	409

780 CMR 1304.0 BUILDING ENVELOPE REQUIREMENTS

1304.1 General. Walls, roof assemblies, floors, glazing, and floor slabs which are part of the *building envelope* shall meet the requirements of 780 CMR 1304.1, 1304.3, 1304.4 and either:

1. 780 CMR 1304.2, Prescriptive Building Envelope Criteria, provided that:
   a the building is less than 4 stories in height above grade;
   b. the *vertical fenestration area* does not exceed 50% of the *gross wall area* for each *space conditioning category*; and,
   c. the *skylight fenestration area* does not exceed 3% of the *gross roof area* for each *space-conditioning category*; or,
2. 780 CMR 1304.5, Building Envelope Trade-off Option.

1304.1.1 Classification of Walls. Walls associated with the *building envelope* shall be classified in accordance with 780 CMR 1304.1.1.1, 1304.1.1.2 or 1304.1.1.3.

1304.1.1.1 Above-grade Walls. Above-grade walls are those walls covered by 780 CMR 1304.2.1 on the exterior of the building and completely above grade or the above-grade portion of a basement or first-story wall that is more than 15% above grade.

1304.1.1.2 Below-grade Walls. Below-grade walls covered by 780 CMR 1304.2.9 are basement or first-story walls associated with the exterior of the building that are at least 85% below grade.

1304.1.1.3 Interior Walls. Interior walls covered by 780 CMR 1304.2.10 are those walls not on the exterior of the building and that separate conditioned and unconditioned space.

1304.1.2 Moisture Control. The design of buildings for energy conservation shall not create conditions of accelerated deterioration from moisture condensation.

A vapor retarder shall be installed on the winter warm side of walls, ceilings and floors enclosing a conditioned space. Batt/blanket insulation with a vapor retarder attached shall be attached to the winter warm sides or faces of wall studs, sole plates, top plates, lintels and headers at intervals of eight inches on center to prevent convection loops through the insulation. Where batt/blanket insulation is of a "friction fit" design and a sheet vapor retarder is employed, the vapor retarder shall be affixed to the interior face of the wall studs, sole plates, top plates, lintels and headers winter warm side in accordance with the vapor retarder manufacturer's recommendations.

All other envelope building materials and finishes installed towards the cooler, exterior side of the wall shall have water vapor permeance at least ten times greater than the interior vapor retarder material.

Exceptions:

1. Materials to the exterior of a ventilated rainscreen cavity may have any permability.
2. Envelope systems that maintain the temperature of potential condensing surfaces (typically the interface of exterior sheathing with cavity insulation) above the dewpoint temperature of the interior air.

3. Envelope systems that maintain the moisture content of all building materials that comprise the assembly to the interior of the water-resistive barrier below the equilibrium moisture content the materials would achieve when exposed to relative humidity of 80%.

4. Buildings with unusual interior design conditions (such as continually refrigerated buildings, ice rinks, cold storage) shall demonstrate compliance by the method in 780 CMR 1304.1.2, Exception 3.

1304.2 Prescriptive Building Envelope Criteria. The building envelope components shall meet each of the applicable requirements in Tables 1304.2.1-12, based on the climate zone and the percentage of wall that is glazed. The climate zone shall be determined based on the county in accordance with 780 CMR 1302, Tables 1302.1 and 1302.2. The percentage of wall that is glazed shall be determined by dividing the aggregate area of rough openings or unit dimensions for *fenestration* (windows and glazed doors) in all the above grade walls associated with the building envelope by the total gross area of all above grade exterior walls that are part of the building envelope. In buildings with multiple types of building envelope construction, each building envelope construction type shall be evaluated separately.

1304.2.1 Above Grade Walls. The minimum thermal resistance (R-value) of the insulating material installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Tables 1304.2.1-12 based on framing type and construction materials used in the wall assembly. Where both cavity and continuous insulation values are provided in Tables 1304.2.1-12, both requirements shall be met. Masonry walls shall be considered "framed walls" when weighing less than 35 psf of wall area.

1304.2.2 Non-glazed Doors. When the total area of non-glazed doors is greater than 5% of the total opaque wall area, the area of non-glazed doors above 5% shall be insulated as an opaque wall or an adjustment shall be made in the thermal resistance of the wall to address any thermal deficiency created by the doors.

1304.2.3 Windows and Glass Doors. The maximum solar heat gain coefficient (SHGC) and thermal transmittance (U-value) of window assemblies and glass doors located in the building envelope shall be as specified in Tables 1304.2.1-12 based on the window projection factor.

The window projection factor shall be determined in accordance with Equation 1304.2.3.

Equation 1304.2.3

$$PF = A/B$$

Where:

PF = Projection factor (decimal).

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

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

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

1304.2.4 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 Tables 1304.2.1-12 based on construction materials used in the roof assembly.

1304.2.5 Skylights. Skylights located in the building envelope shall be limited to 3% of the gross roof assembly area and shall have a maximum thermal transmittance (U-value) of the skylight assembly as specified in Tables 1304.2.1-12.

1304.2.6 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 Tables 1304.2.1-12 based on construction materials used in the floor assembly.

1304.2.7 Slabs on Grade. The minimum thermal resistance (R-value) of the insulation around the perimeter of the slab floor on grade shall be R-5. The insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. Insulation on the outside of the foundation wall shall extend downward from the top of the slab for a minimum of 48 in. Insulation on the inside of the foundation wall shall extend downward to at least the bottom of the slab and then horizontally for a minimum total distance of 48 in. In addition, the entire area of the slab on grade shall be insulated with a minimum of R-5 rigid insulation in the following buildings. buildings of use group E, including daycare; buildings of use groups R-1, R-2, I-1 and I-2, and; college and university buildings of B and A use groups.

Exception. For a monolithic slab on grade floor, the insulation shall extend from the top of the slab on grade to the bottom of the footing. Continuous under-slab insulation shall be provided per 780 CMR 1304.2.8.

1304.2.8 Slabs below Grade. The entire area of a floor slab which is below grade and is in contact

with the ground shall be insulated with a minimum of R-5 rigid insulation in the following buildings. buildings of use group E, including daycare; buildings of use groups R-1, R-2, I-1 and I-2, and; college and university buildings of B and A use groups.

1304.2.9 Below Grade Walls. The minimum thermal resistance of the insulating material installed in, or continuously on, below grade walls of conditioned spaces shall be R-5, and shall extend from the top of the wall to the depth of the bottom of the floor slab.

1304.2.10 Interior Walls. The minimum thermal resistance (R-value) of the insulating material installed in the wall cavity or continuously on the interior walls separating *conditioned space* from *unconditioned space* shall be as specified in Tables 1304.2.1, 1304.2.5, and 1304.2.9 for above grade walls, regardless of glazing area, based on framing type and construction materials used in the wall assembly.

TABLE 1304.2.1 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 12a
Glazing Area 10% or less of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-11 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	Any	Any	
0.25 <= PF < 0.50	Any	Any	
PF >= 0.50	Any	Any	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-25	R-17	
Concrete Slab or Deck	NA	R-16	
Metal Purlin with Thermal Break	R-25	R-17	
Metal Purlin w/o Thermal Break	NA	R-17	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-19	R-16	
Concrete Slab or Deck	NA	R-16	
Slab, Perimeter, and Below-Grade Wall	R-5		

* For masonry walls, average R-value shall be calculated based on the assumption of isothermal planes, using methodology in 2005 ASHRAE Fundamentals Handbook, Chapter 25.

TABLE 1304.2.2 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 12a
Glazing Area Over 10% but not greater than 25% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-11 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.6	0.6	
0.25 <= PF < 0.50	0.7	0.6	
PF >= 0.50	Any	0.6	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-25	R-19	
Non-wood Joist/Truss	R-25	R-20	
Concrete Slab or Deck	NA	R-19	
Metal Purlin with Thermal Break	R-30	R-20	
Metal Purlin w/o Thermal Break	NA	R-20	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-19	R-16	
Concrete Slab or Deck	NA	R-16	
Slab, Perimeter, and Below-Grade Wall	R-5		

TABLE 1304.2.3 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 12a
Glazing Area Over 25% but not greater than 40% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-11 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.5	0.5	
0.25 <= PF < 0.50	0.6	0.5	
PF >= 0.50	0.7	0.5	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-30	R-23	
Non-wood Joist/Truss	R-30	R-24	
Concrete Slab or Deck	NA	R-23	
Metal Purlin with Thermal Break	NA	R-24	
Metal Purlin w/o Thermal Break	NA	R-24	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-19	R-16	
Concrete Slab or Deck	NA	R-16	
Slab, Perimeter, and Below-Grade Wall	R-5		

* For masonry walls, average R-value shall be calculated based on the assumption of isothermal planes, using methodology in 2005 ASHRAE Fundamentals Handbook, Chapter 25.

TABLE 1304.2.4 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 12a
Glazing Area Over 40% but not greater than 50% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-13 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.4	0.4	
0.25 <= PF < 0.50	0.5	0.4	
PF >= 0.50	0.7	0.4	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-30	R-23	
Non-wood Joist/Truss	R-30	R-24	
Concrete Slab or Deck	NA	R-23	
Metal Purlin with Thermal Break	R-30	R-24	
Metal Purlin w/o Thermal Break	R-38	R-24	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-19	R-16	
Concrete Slab or Deck	NA	R-16	
Slab, Perimeter, and Below-Grade Wall	R-5		

TABLE 1304.2.5 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 13a
Glazing Area 10% or less of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-13 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	Any	0.7	
0.25 <= PF < 0.50	Any	0.7	
PF >= 0.50	Any	0.7	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-14	
Non-wood Joist/Truss	R-19	R-15	
Concrete Slab or Deck	NA	R-14	
Metal Purlin with Thermal Break	R-25	R-15	
Metal Purlin w/o Thermal Break	NA	R-15	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-25	R-17	
Concrete Slab or Deck	NA	R-17	
Slab, Perimeter, and Below-Grade Wall	R-5		

* For masonry walls, average R-value shall be calculated based on the assumption of isothermal planes, using methodology in 2005 ASHRAE Fundamentals Handbook, Chapter 25.

TABLE 1304.2.6 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 13a
Glazing Area Over 10% but not greater than 25% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-13 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.6	0.6	
0.25 <= PF < 0.50	0.7	0.6	
PF >= 0.50	Any	0.6	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-25	R-19	
Non-wood Joist/Truss	R-25	R-20	
Concrete Slab or Deck	NA	R-19	
Metal Purlin with Thermal Break	R-30	R-20	
Metal Purlin w/o Thermal Break	NA	R-20	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-25	R-17	
Concrete Slab or Deck	NA	R-17	
Slab, Perimeter, and Below-Grade Wall	R-5		

TABLE 1304.2.7 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 13a
Glazing Area Over 25% but not greater than 40% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-13 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.5	0.5	
0.25 <= PF < 0.50	0.6	0.5	
PF >= 0.50	0.7	0.5	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-30	R-23	
Non-wood Joist/Truss	R-30	R-24	
Concrete Slab or Deck	NA	R-23	
Metal Purlin with Thermal Break	NA	R-24	
Metal Purlin w/o Thermal Break	NA	R-24	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-25	R-17	
Concrete Slab or Deck	NA	R-17	
Slab, Perimeter, and Below-Grade Wall	R-5		

* For masonry walls, average R-value shall be calculated based on the assumption of isothermal planes, using methodology in 2005 ASHRAE Fundamentals Handbook, Chapter 25.

TABLE 1304.2.8 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 13a
Glazing Area Over 40% but not greater than 50% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-13 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.4	0.4	
0.25 <= PF < 0.50	0.5	0.4	
PF >= 0.50	0.7	0.4	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-30	R-23	
Non-wood Joist/Truss	R-30	R-24	
Concrete Slab or Deck	NA	R-23	
Metal Purlin with Thermal Break	R-30	R-24	
Metal Purlin w/o Thermal Break	R-38	R-24	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-16	
Non-wood Joist/Truss	R-25	R-17	
Concrete Slab or Deck	NA	R-17	
Slab, Perimeter, and Below-Grade Wall	R-5		

TABLE 1304.2.9 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 14a
Glazing Area 10% or less of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-11 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	Any	0.7	
0.25 <= PF < 0.50	Any	0.7	
PF >= 0.50	Any	0.7	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-19	R-17	
Non-wood Joist/Truss	R-25	R-18	
Concrete Slab or Deck	NA	R-17	
Metal Purlin with Thermal Break	R-30	R-18	
Metal Purlin w/o Thermal Break	NA	R-18	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-25	R-18	
Non-wood Joist/Truss	R-25	R-19	
Concrete Slab or Deck	NA	R-19	
Slab, Perimeter, and Below-Grade Wall	R-5		

* For masonry walls, average R-value shall be calculated based on the assumption of isothermal planes, using methodology in 2005 ASHRAE Fundamentals Handbook, Chapter 25.

TABLE 1304.2.10 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 14a
Glazing Area Over 10% but not greater than 25% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-13 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.5	0.6	
0.25 <= PF < 0.50	0.6	0.6	
PF >= 0.50	0.7	0.6	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-25	R-19	
Non-wood Joist/Truss	R-25	R-20	
Concrete Slab or Deck	NA	R-19	
Metal Purlin with Thermal Break	R-30	R-20	
Metal Purlin w/o Thermal Break	NA	R-20	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-25	R-18	
Non-wood Joist/Truss	R-25	R-19	
Concrete Slab or Deck	NA	R-19	
Slab, Perimeter, and Below-Grade Wall	R-5		

TABLE 1304.2.11 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 14a
Glazing Area Over 25% but not greater than 40% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-13 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.4	0.5	
0.25 <= PF < 0.50	0.5	0.5	
PF >= 0.50	0.6	0.5	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-30	R-23	
Non-wood Joist/Truss	R-30	R-24	
Concrete Slab or Deck	NA	R-23	
Metal Purlin with Thermal Break	NA	R-24	
Metal Purlin w/o Thermal Break	NA	R-24	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-25	R-18	
Non-wood Joist/Truss	R-25	R-19	
Concrete Slab or Deck	NA	R-19	
Slab, Perimeter, and Below-Grade Wall	R-5		

* For masonry walls, average R-value shall be calculated based on the assumption of isothermal planes, using methodology in 2005 ASHRAE Fundamentals Handbook, Chapter 25.

TABLE 1304.2.12 BUILDING ENVELOPE REQUIREMENTS
Climate Zone 14a
Glazing Area Over 40% but not greater than 50% of Above Grade Wall Area

Above-Grade Walls:	**Continuous Insulation (or average insulation value)***	**Metal Framing (c.i. = continuous insulation)**	**Wood Framing**
Framed or Masonry < 35 psf.	R-7	R-13 + R-3 c.i.	R-11
Masonry >= 35 psf.	R-5	R-11 + R-3 c.i.	R-11

Window Assemblies:	**SHGC (maximum)**	**U-Value (maximum)**	
PF < 0.25	0.4	0.4	
0.25 <= PF < 0.50	0.5	0.4	
PF >= 0.50	0.6	0.4	
Skylights - U-Value (maximum)	NA	0.8	

Roof Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-30	R-23	
Non-wood Joist/Truss	R-30	R-24	
Concrete Slab or Deck	NA	R-23	
Metal Purlin with Thermal Break	R-38	R-24	
Metal Purlin w/o Thermal Break	R-38	R-24	

Floor Assemblies. (either/or)	**Insulation Between Framing**	**Continuous Insulation**	
All-Wood Joist/Truss	R-25	R-18	
Non-wood Joist/Truss	R-25	R-19	
Concrete Slab or Deck	NA	R-19	
Slab, Perimeter, and Below-Grade Wall	R-5		

* For masonry walls, average R-value shall be calculated based on the assumption of isothermal planes, using methodology in 2005 ASHRAE Fundamentals Handbook, Chapter 25.

1304.3 Air Leakage.

1304.3.1 Air Barriers. The building envelope shall be designed and constructed with a *continuous air barrier* to control air leakage into, or out of the conditioned space. An air barrier shall also be provided for interior partitions between conditioned space and space designed to maintain temperature or humidity levels which differ from those in the conditioned space by more than 50% of the difference between the conditioned space and design ambient conditions. The *continuous air barrier* shall have the following characteristics:

1. Materials used in the *continuous air barrier* shall have an air permeance not to exceed 0.004 cfm/ft^2 under a pressure differential of 0.3 in. water. (1.57 psf.) (equal to 0.02L/s.m^2 @ 75 Pa.) when tested in accordance with ASTM E 2178. Air barrier materials shall be taped or sealed in accordance with the manufacturer's instructions.
2. It shall be capable of withstanding positive and negative combined design wind, fan and stack pressures on the envelope without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.
3. Air barrier materials shall be maintainable, or, if inaccessible, shall meet durability requirements for the service life of the envelope assembly.
4. The air barrier material of an envelope assembly shall be joined and sealed in a flexible manner to the air barrier material of adjacent assemblies, allowing for the relative movement of assemblies due to thermal and moisture variations and creep. Connection shall be made between:
   a. Foundation and walls.
   b. Walls and windows or doors.
   c. Different wall systems.
   d. Wall and roof.
   e. Wall and roof over unconditioned space.
   f. Walls, floor and roof across construction, control and expansion joints.
   g. Walls, floors and roof to utility, pipe and duct penetrations.

1304.3.2 Air Barrier Penetrations. All penetrations of the air barrier and paths of air infiltration/exfiltration shall be sealed.

1304.3.3 Fenestration and Doors. Air leakage for *fenestration* and *doors* shall be determined in accordance with NFRC 400 or ASTM E 283 @ 1.57 psf (75 Pa.) Air leakage shall be determined by an independent laboratory accredited by a nationally recognized accreditation organization

and shall be certified by the manufacturer. Air leakage shall not exceed 1.0 cfm/ft^2 for glazed swinging entrance doors and for revolving doors, and 0.4 cfm/ft^2 for all other products under a pressure differential of 0.3 inches of water (1.57 psf.)

Exceptions:

1. Field fabricated *fenestration* and *doors* that are weather-stripped.
2. For garage *doors*, air leakage determined by test at standard test conditions in accordance with ANSI/DASMA 105 shall be an acceptable alternate for compliance with air leakage requirements.

1304.3.4 Shaft, Chute, Access Opening, Stairwell and Elevator Lobby Doors. Doors and access openings leading to shafts, chutes, stairwells, and elevator lobbies shall either meet the requirements of 780 CMR 1304.3.3 or shall be equipped with weatherseals.

Exception. Weatherseals on elevator lobby doors are not required when a smoke control system is installed in accordance with 780 CMR 921.7.

1304.3.5 Loading Dock Weatherseals. Cargo *doors* and loading dock *doors* shall be equipped with weatherseals to restrict *infiltration* when vehicles are parked in the doorway.

1304.3.6 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. Interior and exterior *doors* shall have a minimum distance between them of not less than seven feet (2.1 m) when in the closed position.

Exceptions:

1. *doors* not intended to be used as a *building entrance door*, such as doors for mechanical or electrical equipment rooms;
2. *doors* opening directly from a *dwelling unit*;
3. *doors* that open directly from a space less than 3000 ft^2 (200 m^2) in area
4. revolving *doors* or *doors* adjacent to revolving *doors*;
5. *doors* used primarily to facilitate vehicular movement or material handling and adjacent personnel *doors*.

1304.3.7 Air-tight Dampers. Air-tight operable dampers shall be installed where the air barrier is penetrated by:

1. fixed open louvers such as in elevator shafts and machine rooms;
2. mechanical system components which allow infiltration or exfiltration of air when the systems are inactive, such as atrium smoke exhaust systems and make-up air louvers;
3. outside air intakes, exhaust outlets, relief outlets, stair shaft, elevator shaft smoke relief openings, and other similar elements.

Such dampers shall have a leakage no greater than 3cfm/ft^2 at 1.0 in w.g. when tested in accordance with AMCA Standard 500. They shall be set in the closed position, and shall automatically open upon.

1. the activation of any fire alarm initiating device of the building's fire alarm system;
2. the interruption of power to the damper.

1304.3.8 Recessed Lighting Fixtures. When installed in the building envelope, recessed lighting fixtures 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 rated, in accordance with ASTM E 283 no more than 2.0 cfm air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested at 75 Pa or 1.57 lbs./ft.^{2} pressure difference and shall be labeled.

1304.3.9 Envelope Gaps and Cavities. All gaps and cavities between rough framing and door and window heads, jambs, and sills shall be filled with insulation and the window and door frames sealed to air barrier or adjacent assemblies.

1304.4 Insulation General. Where insulation is required in 780 CMR 1304.2 or 1304.5, it shall also comply with 780 CMR 1304.4.1 through 1304.4.5.

1304.4.1 Insulation Installation. Insulation materials shall be installed in accordance with manufacturer's recommendations as to achieve and maintain *rated R-value of insulation*.

Where continuous wall insulation is required in 780 CMR 1304.2 or 1304.5 in multi-story buildings, the insulation must be continuous across floor structures.

Open-blown or poured loose-fill insulation shall not be used in *attic roof* spaces with eave vents when the slope of the ceiling is more than three in twelve unless special provisions are made to prevent settling and maintain an air space for ventilation above the insulation. Baffling of the vent openings shall be provided to deflect the incoming air above the surface of the insulation.

1304.4.2 Substantial Contact. Insulation shall be installed in a permanent manner in *substantial contact* with adjacent surfaces in a manner which will prevent convection of air around the insulation. Flexible batt insulation installed in floor cavities shall be supported in a permanent manner by supports no greater than 24 in. on center.

Batt insulation with integral vapor barrier shall be attached to the winter warm sides or faces of wall studs, sole plates, top plates, lintels and headers at intervals of eight inches on center. Where batt/blanket insulation is of a "friction fit" design and a poly vapor barrier is employed, the vapor barrier shall be affixed to the interior face of the wall studs, sole plates, top plates, lintels and headers (winter warm side) in accordance with the insulation manufacturer's recommendations.

1304.4.3 Recessed Equipment. Lighting fixtures; heating, ventilating, and air-conditioning equipment, including wall heaters, ducts, and plenums; and other equipment shall not be recessed in such a manner to affect the insulation thickness unless:

1. the total combined area affected (including necessary clearances) is less than one% of the opaque area of the assembly, or
2. the entire *roof*, *wall*, or *floor* is covered with insulation to the full depth required or
3. the effects of reduced insulation are included in calculations using an area weighted average method and compressed insulation values from the ASHRAE 1997 Handbook of Fundamentals. In all cases, air leakage through the recessed equipment to the *conditioned space* shall be prevented.

1304.4.4 Location of Roof Insulation. The *roof* shall be insulated in a location other than directly on a suspended ceiling with removable ceiling panels.

1304.4.5 Insulation Protection. Exterior insulation shall be covered with a protective material to prevent damage from sunlight, moisture, landscaping operations, equipment maintenance, and wind. In *attics* and mechanical rooms, a way to access equipment that prevents damaging or compressing the insulation shall be provided. Foundation vents shall not interfere with the insulation.

Insulation materials in ground contact shall have water absorption no greater than 0.3% when tested in accordance with ASTM C272.

Exception. Insulation materials that have a water drainage system included.

1304.5 Building Envelope Trade-off Option. The *building envelope* complies with the standard if the proposed building satisfies the provisions of 780 CMR 1304.1, 1304.3, and 1304.4, and the *envelope performance factor* of the proposed building is less than or equal to the *envelope performance factor* of the budget building. The *envelope performance factor* considers only the *building envelope* components. Schedules of operation, lighting power, equipment power, occupant density, and mechanical systems shall be the same for both the proposed building and the budget building. *Envelope performance factor* shall be calculated using computer programs accepted by the Board of Building Regulations and Standards.

780 CMR 1305.0 HEATING VENTILATION AND AIR CONDITIONING

1305.1 General. 780 CMR 1305.0 covers the design and construction of mechanical systems and equipment serving the building heating, cooling, or ventilating needs.

1305.1.1 Compliance. Compliance with 780 CMR 1305.0 shall be achieved by meeting either 780 CMR 1305.2 or 780 CMR 1305.3.

1305.2 Simple HVAC Systems and Equipment.

1305.2.1 Scope. 780 CMR 1305.2 applies to buildings served by unitary or packaged air conditioners or heat pumps, packaged terminal air conditioners, and packaged furnaces each serving one zone and controlled by a single thermostatic control in the zone served. It also applies to buildings served by packaged boilers and two-pipe heating systems serving one or more zones.

780 CMR 1305.2 does not apply to non-unitary or non-packaged HVAC equipment and systems or to chiller systems.

780 CMR 1305.2 does not apply to buildings in which the outside air quantity capable of being supplied by any individual fan system exceeds 3000 cfm or 70% of the total design supply air quantity for the fan system.

1305.2.2 Calculation of Heating and Cooling Loads. Design loads shall be determined in accordance with the procedures described in Chapters 25 and 26 of the ASHRAE 1997 Handbook of Fundamentals or an approved equivalent computation procedure.

1305.2.2.1 Equipment and System Sizing. Heating and cooling equipment and systems capacity shall not exceed the loads calculated in accordance with 780 CMR 1305.2.2. A single piece of equipment providing both heating and cooling shall satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

1305.2.3 HVAC Equipment Performance Requirements. Packaged air conditioners and heat pumps with capacity greater than 240,000 Btu/h, ground-source and ground water source heat pumps, and duct furnaces and unit heaters shall meet the minimum efficiency requirements of Tables 1305.3.3(1), (2), and (4), when tested and rated in accordance with the referenced 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 and/or performance requirements are provided, the equipment shall satisfy all stated requirements.

Other new equipment within the scope of 780 CMR 1305.2 is required to meet efficiency standards administered by the federal government. The efficiency of used equipment within the scope of the federal standards shall be verified through data furnished by the manufacturer.

Equipment not required to meet efficiency standards administered by the federal government, and not in Tables 1305.3.3(1), (2), and (4) may be used, and have no minimum performance requirements.

1305.2.4 Temperature and Humidity Controls:

1305.2.4.1 Temperature Controls. Each heating and cooling system shall have at least one programmable thermostat. The thermostat shall have the capability to setback or shutdown the system based on day of the week and time of day and a readily accessible manual override that will return to the pre-setback or shutdown schedule without reprogramming. Thermostatic controls shall be capable of providing a temperature range or dead band of at least 5°F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

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

Where heating and cooling to a zone are controlled by separate zone thermostatic controls located within the zone, means (such as limit switches, mechanical stops, or, for *direct digital control* (DDC) systems, software programming) shall be provided to prevent the heating set point from exceeding the cooling set point minus any applicable proportional band.

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

1305.2.4.2 Humidity Controls. When humidistats are installed they shall prevent the use of fossil fuel or electric power to achieve a humidity below 60% when the system controlled is cooling, and above 30% when the system controlled is heating.

1305.2.5 Hydronic System Controls. Hydronic heating systems of at least 300,000 Btu/h design capacity supplying heated water to comfort conditioning systems shall include controls that have the capability to automatically reset the supply water temperatures by representative building loads (including return water temperature) or by outside air temperature.

Exception. systems which vary water flow in compliance with 780 CMR 1305.3.5.4.

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 of greater than 500,000 Btu/h design capacity shall include either a multi-staged or modulating burner.

1305.2.6 Ventilation. Natural or mechanical ventilation shall be provided in accordance with the mechanical code listed in 780 CMR 35. Any mechanical ventilation system shall have the capability to reduce the outdoor air supply to the minimum required by the mechanical code listed in 780 CMR 35.

1305.2.6.1 Distributed Fan Systems. Where mechanical ventilation is provided by multiple fan systems located in a plenum or other enclosed space, outdoor air shall be ducted directly to each individual fan system.

1305.2.6.2 Shutoff Dampers. Outdoor air supply ducts and exhaust ducts associated with the mechanical ventilation system shall be provided with automatic means to reduce and shutoff air flow.

Exceptions:

1. Systems serving areas designed for continuous operation .
2. Individual systems with an outside air intake or exhaust capacity of 300 cfm or less.
3. Systems with readily accessible manual dampers.

1305.2.7 Economizers. Each system over 65,000 Btu/h cooling capacity shall have an economizer that will automatically shut off the cooling system and allow 100% of the supply air to be outdoor air.

1305.2.8 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 envelope. 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 R-5 insulation. Required R-values are the "labeled" R-values for such ducts.

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.
3. Exhaust air ducts.
4. Outside air supply ducts located outside of the building envelope.

All joints, longitudinal and transverse seams, and connections in duct work, shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes. Tapes and mastics used with rigid fibrous glass ducts shall be listed and labeled in accordance with UL 181A. Tapes and mastics used with flexible air ducts shall be listed and labeled in accordance with UL 181B. Duct tape is not permitted as a sealant on any metal ducts.

1305.2.9 Piping Insulation. All low pressure side refrigerant piping shall be insulated with ¾ in. of insulation, hot water piping for comfort conditioning shall be insulated with one inch of insulation, and steam system piping shall be insulated with two inches of insulation. All insulation shall have a conductivity not exceeding 0.27 Btu-in./hr-ft^2 °F.

1305.3 Complex HVAC Systems and Equipment:

1305.3.1 Scope. 780 CMR 1305.3 applies to all HVAC systems and equipment other than those covered in 780 CMR 1305.2.

1305.3.2 Calculation of Heating and Cooling Loads. Design loads shall be determined in accordance with the procedures described in Chapters 25 and 26 of the *ASHRAE Handbook of Fundamentals.* Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are utilized in the HVAC system in accordance with the *ASHRAE HVAC Systems and Equipment Handbook*. Alternatively, design loads shall be determined by an approved equivalent computation procedure.

1305.3.2.1 Equipment and System Sizing. Heating and cooling equipment and system capacity shall not exceed the loads calculated in accordance with 780 CMR 1305.3.2.

1305.3.3 HVAC Equipment Performance Requirements. Equipment shall be newly purchased or shall meet the minimum efficiency requirements of Tables 1305.3.3(1) through 1305.3.3(11), as applicable, when tested and rated in accordance with the referenced test procedure. The efficiency shall be verified through data furnished by the manufacturer or through an approved certification program. Where multiple rating conditions and/or performance requirements are provided, the equipment shall satisfy all stated requirements.

Certain new equipment within the scope of 780 CMR 1305.3.3 is required to meet efficiency standards administered by the federal government. The efficiency of used equipment within the scope of the federal standards shall be verified through data furnished by the manufacturer.

Equipment not required to meet efficiency standards administered by the federal government, and not in Tables 1305.3.3(1) through 1305.3.3(11) may be used, and have no minimum performance requirements.

1305.3.3.1 Duct furnaces and Unit Heaters. Warm air duct furnaces and unit heaters shall have an intermittent ignition device, maximum jacket losses of 0.75% of the equipment input rating, and power venting or a flue damper. When combustion air is drawn from the conditioned space a vent damper shall be permitted to be used in lieu of the required flue damper.

TABLE 1305.3.3(1) UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Conditioners, Air Cooled	<65,000 Btu/h[d]	Split system	10.0 SEER	ARI 210/240
		Single package	9.7 SEER	
	≥65,000 Btu/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[b]	
	> 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[b]	ARI 210/240
	≥65,000 Btu/h and <135,000Btu/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] 13.1 IPLV[c]	

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

a. The IECC contains a complete specification of the referenced test procedure, including the references year version of the test procedure
b. IPLVs are only applicable to equipment with capacity modulation.
c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
d. Single-phase air-cooled air conditioners <65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA), SEER values are those set by NAECA.

TABLE 1305.3.3(2) UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Cooled, (Cooling Mode)	<65,000 Btu/h[d]	Split System	10.0 SEER	ARI 210/240
		Single Package	9.7 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[b] 9.2 IPLV[b]	
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	6.8 HSPF	ARI 210/240
		Single Package	6.6 HSPF	
	≥65,000 Btu/h and <135,000 Btu/h (Cooling capacity)	47°F db/43° wb outdoor air	3.2 COP	
	≥135,000 Btu/h (Cooling capacity)	47°F db/43° 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

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. The IECC contains a complete specification of the referenced test procedure, including the references year version of the test procedure
b. IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.
c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
d. Single-phase air-cooled air conditioners <65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA), SEER values are those set by NAECA.

TABLE 1305.3.3(3) PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS

Equipment Type	Size Category (Input)	Sub-Category 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	All capacities	95°F db outdoor air	10.8 - (0.213 • Cap/1000 EER	
PTHP (Cooling mode) New Construction	All capacities	-	3.2 - (0.026 • Cap/1000 COP	
PTHP (Cooling mode) Replacements	All capacities	-	2.9 - (0.026 • Cap/1000 COP	

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. The IECC contains a complete specification of the referenced test procedure, including the references 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 os greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
c. Replacement units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) high and less than 42 inches (1067 mm) wide.

TABLE 1305.3.3(4) WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category (Input)	Sub-Category or Rating Condition[a]	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[c]	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[c]	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: °C = [(°F - 32]/1.8, 1 British thermal unit per hour - 0.2931 W.

a. The IECC contains a complete specification of the referenced test procedure, including the references 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 oor equal to 65,000 Btu/h [19 kW] 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_t = Combination efficiency. Units must also include an IID, have jackets not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

g. E_t = Thermal efficiency. Units must also include an IID, have jacketed loses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

TABLE 1305.3.3(5) BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category 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	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	Hot Water	83% E_c	
		Steam	83% E_c	
Oil-Fired (Residual)	≥ 300,000 Btu/h and ≥ 2,500,000 Btu/h	Minimum Capacity[a]	83% E_c	H.I. HBS
	> 2,500,000 Btu/h[f]	Hot Water	83% E_c	
		Steam	83% E_c	

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

a. The IECC contains a complete specification of the references test procedure, including the references 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% flue losses). See reference document for detailed information.

d. E_t = Thermal efficiency. See reference document for detailed information.

e. Alternate test procedures used at the manufacturer's option are ASME PTC-4.1 for units over 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.

TABLE 1305.3.3(6) CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Minimum Efficiency[b]	Test Procedure[a]
Condensing Units, Air cooled	≥ 135,000 Btu/h	10.1 EER 11.2 IPLV	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. The IECC contains a complete specification of the references test procedure, including the references year version of the test procedure.

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

TABLE 1305.3.3(7) 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.

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

a. The IECC contains a complete specification of the references test procedure, including the references 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.

TABLE 1305.3.3(8) 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]	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	5.29	6.45	6.57
41	75	34	5.59	5.82	5.98	6.19	6.34	6.44
46	80	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
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	7.76	5.87	5.95
46	85	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
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 $\triangle T$[b]			14.04	11.23	9.36	7.02	5.62	4.68

For SI: °C - [(°F) - 32]/1.8, 1 gallon per minute - 3.785L/min., 1 ton - 12,000 British thermal unit per hour - 3,517 kW.

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

b. Condenser $\triangle T$ - 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 $\triangle T$ + Lift

$COP_{adj} = K_{adj} x - COP_{std}$

TABLE 1305.3.3(9) 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]	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
46	80	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
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	5064	5.8	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.13	6.11
46	85	39	5.23	5.54	7.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
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 $\triangle T$[b]			1.4.04	11.23	9.36	7.02	5.62	4.68

For SI: °C - [(°F) - 32]/1.8, 1 gallon per minute - 3.785L/min., 1 ton - 12,000 British thermal unit per hour - 3,517 kW.

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

b. Condenser $\triangle T$ - 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 $\triangle T$ + Lift COP_{adj} - $K_{adj}x$ - COP_{std}

TABLE 1305.3.3(10) COPS AND IPLVS FOR NONSTANDARD CENTRIFUGAL CHILLERS > 300 TONS

CENTRIFUGAL CHILLERS ,> 300Tons COP_{std}= 6.1								
Leaving chilled water temperature (°F)	Entering condenser water temperature (°F)	Lift[a]	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	6.80	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
46	80	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
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
46	85	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
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	5.68	5.26	5.58	5.90	6.07	6.17
Condenser $\triangle T$[b]			14.04	11.23	9.36	7.02	5.62	4.68

For SI: °C - [(°F) - 32]/1.8, 1 gallon per minute - 3.785L/min., 1 ton - 12,000 British thermal unit per hour - 3,517 kW.

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

b. Condenser $\triangle T$ - 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 $\triangle T$ + Lift

$COP_{adj} = K_{adj}x = COP_{std}$

TABLE 1305.3.3(11) PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Sub-Category 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
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
Air Cooled Condensers	All	125 °F Condensing Temperature R22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering Drybulb	≥ 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.

wb - wet-bulb temperature, °F

a. For purposes of this table, cooling tower performances 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, The IECC contains a complete specification of the referenced test procedure, including the references year version of the test procedure

1305.3.4 Temperature and Humidity Controls.

1305.3.4.1 Thermostatic Controls. The supply of heating and cooling energy to each zone shall be individually controlled by thermostatic controls capable of responding to temperature within the zone.

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

1. the perimeter system includes at least one thermostatic control zone for each building exposure of the building (face within +/- 45°) having exterior walls facing only one orientation for more than 50 contiguous feet and,
2. the perimeter system heating and cooling supply is controlled by thermostatic controls located within the zone(s) served by the system.

1305.3.4.2 Zone Thermostatic Control capabilities:

1305.3.4.2.1 Set Point Overlap Restriction. Where used to control both heating and cooling, zone thermostatic controls shall be capable of providing a temperature range or dead band of at least 5°F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

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

Where heating and cooling to a zone are controlled by separate zone thermostatic controls located within the zone, means (such as limit switches, mechanical stops, or, for *direct digital control* (DDC) systems, software programming) shall be provided to prevent the heating set point from exceeding the cooling set point minus any applicable proportional band.

1305.3.4.2.2 Off-hour Controls. HVAC systems shall have setback and automatic controls.

Exceptions:

1. Systems that serve areas that operate continuously, or
2. Systems with full load demands not exceeding 2 kW when having a readily accessible manual shut off switch.

Thermostatic setback controls shall have the capability to setback or temporarily operate the system to maintain zone temperatures down to 55 °F or up to 85 °F.

HVAC systems shall be equipped with an automatic timeclock or programmable control that is capable of starting and stopping the system for seven different daily schedules per week, retaining programming and time setting during loss of power for a period of at least ten hours, and has a manual override that allows temporary operation of the system for up to two hours; a manually-operated timer capable of being adjusted to operate the system for up to two hours; or an occupancy sensor.

1305.3.4.3 Zone Isolation. Systems that serve zones that will have the capability to operate non- simultaneously shall include isolation

devices and controls to shut off or set back the supply of ventilation air, heating, and cooling to each zone independently. For offices, each isolation area shall be no larger than 25,000 ft^2 of conditioned floor area nor include more than one floor. For all other occupancies, isolation areas shall be no larger than a single *zone*, a single tenant space, or 5000 ft^2 of conditioned floor area, whichever is larger.

Exception. Exhaust air and outside air connections to fan systems of 5,000 cfm and smaller.

1305.3.4.4 Humidifier Preheat. Humidifiers with preheating jackets mounted in the air stream shall be provided with an automatic valve to shut off preheat when humidification is not required.

1305.3.4.5 Humidification and Dehumidification. Where a *zone* is served by a system or systems with both humidification and dehumidification capability, means (such as limit switches, mechanical stops, or, for *direct digital control* (DDC) systems, software programming) shall be capable of preventing simultaneous operation of humidification and dehumidification equipment.

Exceptions:

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

1305.3.4.6 Simultaneous Heating and Cooling. Zone thermostatic and humidistatic controls shall be capable of operating in sequence the supply of heating and cooling energy to the zone. Controls shall be capable of preventing reheating; recooling; mixing, or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled either by economizer operation or mechanical cooling.

Exceptions:

1. Variable air volume systems which, during periods of occupancy, are designed to reduce the primary air supply to each zone to a minimum before reheating, recooling, or mixing takes place.
2. Zones where special pressurization relationships or cross-contamination requirements are such that variable air volume systems are impractical.
3. At least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
4. Zones where special humidity levels are required to satisfy process needs.
5. Zones with a peak supply air quantity of 300 cfm or less and where the flow rate is less than 10% of the total fan system flow rate.
6. 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 780 CMR 1305.3.6.

1305.3.4.7 Temperature Reset for Air Systems. Air systems supplying heated or cooled air to multiple zones shall include controls that have the capability to automatically reset the supply air in response to measured parameters representative of building loads or by outside air temperature. Temperature shall be capable of being reset by at least 25% of the design supply air to room air temperature difference.

Exception. Systems that comply with 780 CMR 1305.3.4.6 without using Exception 1., 2. or 6.

1305.3.5 Hydronic System 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 780 CMR 1305.3.5.1 through 1305.3.5.3.

Hydronic heating systems comprised of multiple packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include automatic controls capable of sequencing operation of the boilers.

Hydronic heating systems comprised of a single boiler and greater than 500,000 Btu/h design capacity shall include either a multi-staged or modulating burner.

1305.3.5.1 Three-pipe System. Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

1305.3.5.2 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 outside air temperature; be designed to and provided with controls that will allow operation in one mode for at least four hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F apart.

1305.3.5.3 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 providing a heat pump water supply temperature dead band of at least 20˚F 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 low leakage positive closure dampers shall be provided. If an open-circuit cooling 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, then 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 ten hp 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 shall be permitted.

1305.3.5.4 Hydronic Variable Flow Systems. HVAC pumping systems that include control valves designed to modulate or step open and closed as a function of load shall be designed for variable fluid flow and be capable of reducing pump flow rates to 50% or less of the design flow rate.

1305.3.5.5 Maximum Power Use. Individual pumps serving variable flow systems having pump motors greater than 50 hp shall include controls that are capable of limiting pump motor demand to no more than 30% of design power input at 50% of design water flow.

1305.3.6 Ventilation. Ventilation, either natural or mechanical, shall be provided in accordance with the mechanical code listed in 780 CMR 35.00. Where mechanical ventilation is provided the system shall provide the capability to reduce the outdoor air supply to the minimum required by the mechanical code listed in 780 CMR 35.00.

1305.3.6.1 System Controls. Mechanical ventilation systems shall be provided with manual or automatic controls that will allow the fan system to operate whenever the spaces served are occupied. Air conditioning systems that supply required ventilation air shall be provided with controls designed to automatically maintain the required outdoor air supply rate during occupancy.

1305.3.6.2 Ventilation Controls for High-Occupancy Areas. Systems with design outside air capacities greater than 3000 cfm serving areas having an average design occupancy density exceeding 100 people per 1000 ft^2 shall include means to automatically reduce outside air intake below design rates when spaces are partially occupied. Ventilation controls shall be in compliance with the mechanical code listed in 780 CMR 35.

Exception. fan systems with energy recovery.

1305.3.6.3 Distributed Fan Systems. Where mechanical ventilation is provided by multiple fan systems located in a plenum or other enclosed space, outdoor air shall be ducted directly to each individual fan system.

1305.3.6.4 Outdoor Air Intake Control. Variable air volume systems shall have controls that are capable of maintaining total system outdoor airflow at not less than 90% of the outdoor air supply rates required by 780 CMR 1305.3.6.

1305.3.6.5 Zone Minimum Air Flow. Variable air volume zone controls shall maintain the hourly average outdoor supply air rate at not less than the minimum supply rate required by 780 CMR 1305.3.6 under any thermal load condition expected to occur when the spaces served are occupied.

1305.3.6.6 Shutoff Damper Controls. Both outdoor air supply and exhaust ducts associated with the mechanical ventilation system shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use.

Exceptions:
1. Gravity (non-motorized) dampers installed in buildings less than three stories in height above grade.
2. Individual supply systems with an outside air intake or exhaust capacity of 300 cfm or less.

1305.3.7 Economizers. Each cooling system including the fan with a total cooling capacity of at least 65,000 Btu/h shall have an air or water economizer.

Cooling fan systems with a total cooling capacity less than 65,000 Btu/hr shall have an air or water economizer in buildings three stories and taller where the total cooling capacity of all such systems exceeds 2,400,000 Btu/h or 10% of the total installed cooling capacity, whichever is larger.

Exceptions:
1. Systems that include gas phase air cleaning in order to meet ventilation requirements.
2. Where more than 25% of the air designed to be supplied by the system is to spaces that are designed to be humidified above a 35°F (2°C) dewpoint temperature in order to satisfy process needs.

3. Systems that include a condenser heat recovery system complying with 780 CMR 1305.3.12.
4. Systems that serve residential spaces where the system capacity is less than 325,000 cfm.
5. Systems that serve spaces whose sensible cooling load at design conditions, excluding transmission and infiltration loads, is less than or equal to transmission and infiltration losses at an outdoor temperature of 60°F.
6. Systems expected to operate less than 20 hours per week.
7. Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.

1305.3.7.1 Air Economizers. Air economizers shall be designed to modulate outside air and return air dampers to provide up to the design supply air quantity as outside air.

Economizer dampers shall be capable of being sequenced with the mechanical cooling equipment and shall be controlled by other than mixed air temperature alone. The use of mixed air temperature limit control shall be permitted for systems controlled from space temperature (such as single-*zone* systems).

Air economizers shall be designed to automatically reduce the minimum supply of outside air to the minimum quantities required by 780 CMR 1305.3.6 when the use of outside air will no longer reduce cooling energy usage. Means shall be provided to relieve or exhaust excess return air during air economizer operation. The relief air outlet shall be located to avoid reintroduction of exhaust air into the building.

Controls shall be permitted to be installed to reduce the quantity of outdoor air to prevent coil frosting at the lowest stage of compressor unloading.

1305.3.8 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 envelope. 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 R-5 insulation. Required R-values are the "labeled" R-values for such ducts.

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.
3. Exhaust air ducts.
4. Outside air supply ducts located outside of the building envelope.

All joints, longitudinal and transverse seams, and connections in duct work, shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes. Tapes and mastics used with rigid fibrous glass ducts shall be listed and labeled in accordance with UL 181A. Tapes and mastics used with flexible air ducts shall be listed and labeled in accordance with UL 181B. Duct tape is not permitted as a sealant on any metal ducts.

Ducts designed to operate at static pressures in excess of three inch. water column shall be leak-tested in accordance with the SMACNA HVAC air duct leakage test manual with the rate of air leakage less than or equal to 6.0 as determined in accordance with Equation 1305.3.8.

Equation 1305.3.8

$$L_{max} = C_L P^{0.65}$$

Where:

L_{max} = the maximum permitted leakage in cfm per 100 ft^2 duct surface

C_L = 6 for square/rectangular sheetmetal or fibrous ducts, 3 for round/oval sheetmetal, fibrous or flexible ducts

P = test pressure which shall be equal to the design duct pressure class rating in inches w.c.

1305.3.9 Piping Insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 1305.3.9.

Exceptions:
1. Factory-installed piping within HVAC equipment tested and rated in accordance with 780 CMR 1305.3.3.
2. Piping that conveys fluids that have a design operating temperature range between 55ºF and 105ºF
3. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electrical power.
4. Hot water runout piping not exceeding four feet. in length and one inch in diameter or less between the control valve and HVAC coil.

TABLE 1305.3.9 MINIMUM PIPE INSULATION THICKNESS[a]

Fluid Design Operating Temp. Range (°F)	Insulation Conductivity		Nominal Pipe or Tube Size (in.)				
	Conductivity Btu*in./(h*ft2*°F)	Mean Rating Temp. (˚F)	< 1	1 to <1½	1½ to < 4	4 to < 8	>= 8
Heating Systems (Steam, Steam Condensate and Hot Water)							
>350	0.32-0.34		250	2.5	3.0	4.0	4.0
251-350	0.29-0.32		200	1.5	2.5	3.0	3.0
201-250	0.27-0.30		150	1.5	1.5	2.0	2.0
141-200	0.25-0.29		125	1.0	1.0	1.5	1.5
105-140	0.22-0.28		100	0.5	0.5	1.0	1.0
Domestic and Service Hot Water Systems							
105 and Greater	0.22-0.28		100	0.5	0.5	1.0	1.0
Cooling Systems (Chilled Water, Brine, and Refrigerant)							
40-60	0.22-0.28		100	0.5	0.5	1.0	1.0
Below 40	0.22-0.28		100	0.5	1.0	1.5	1.5

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

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

Where:
T = minimum insulation thickness (in.);
r = actual outside radius of pipe (in.);
t = insulation thickness listed in this table for applicable fluid temperature and pipe size;
K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu*in.(h*ft^2*°F)]; and
k = the upper value of the conductivity range listed in Table 1305.3.9 for the applicable fluid temperature.

1305.3.10 Fan System Power. The ratio of the nameplate *fan system power* to the supply fan air flow rate of each HVAC system at design conditions shall not exceed the requirements shown in Table 1305.3.10. *Fan system power* shall be adjusted in accordance with Equation 1305.3.10 for the additional power required by process loads, air treatment or filtering systems with design pressure drops over 1 in. w.c. when filters are clean, heat recovery coils or devices, or direct evaporative humidifiers/coolers.

Equation 1305.3.10

Adjusted fan system power = Fan system power - HP Credit

$$\text{HP Credit (hp)} = \text{Sum of } [CFM_n \times (SP_n - 1.0)/3718] + \text{Sum of } [CFM \times SP_{HR}/3718]$$

Where:
CFM_n = Supply air volume of the unit with the filtering system, cfm
SP_n = Air pressure drop of the filtering system when filters are clean, in. w.c.
SP_{HR} = Air pressure drop of heat recovery coils or direct evaporative humidifier/cooler, in. w.c.

TABLE 1305.3.10 FAN POWER LIMITATION

Supply Air Volume	Allowable Nameplate Motor Power	
	Constant Air Volume	Variable Air Volume
< 20,000 cfm	1.2 hp/1,000 cfm	1.7 hp/1,000 cfm
≥ 20,000 cfm	1.1 hp/1,000 cfm	1.5 hp/1,000 cfm

1305.3.10.1 Variable Air Volume (VAV) Fan Control. Individual VAV fans with motors 25 hp and larger shall have controls or devices that will result in fan motor demand of no more than 30% of design wattage at 50% of design air volume when static pressure set point equals ⅓ of the total design static pressure, based on manufacturer's certified fan data.

Static pressure sensors used to control variable air volume fans shall be placed in a position such that the controller set point is not able to exceed ⅓ the total design fan static pressure. If this results in the sensor being located downstream of splits in primary duct runs, multiple sensors shall be installed in each major duct.

For systems with direct digital control at the zone level, static pressure set points shall be capable of being reset based on the zone requiring the most pressure.

1305.3.10.2 Fan-Powered VAV Boxes. Fan-Powered VAV boxes shall be capable of being controlled to shut off when the primary system is off except as required to maintain the *zone* at setback temperatures.

1305.3.11 Heat Rejection Equipment.

1305.3.11.1 General. 780 CMR 1305.3.11 applies to heat rejection equipment used in comfort cooling systems covered in Table 1305.3.3.

1305.3.11.2 Fan Speed Control. Each fan associated with a heat rejection device covered in Table 1305.3.3e and powered by a motor of 7.5 hp or larger shall have a fan speed control with the capability to operate that fan at two-thirds of full speed or less, and shall have controls that are capable of automatically changing the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

Exceptions:

1. Condenser fans serving multiple refrigerant circuits.
2. Condenser fans serving flooded condensers.
3. Up to ⅓ of the fans on a condenser or tower with multiple fans where the lead fans comply with the speed control requirement

1305.3.12 Exhaust Air Energy Recovery. HVAC fan systems that have both a design supply air capacity of 5000 cfm or greater and have a minimum outside air supply of 70% or greater of the design supply air quantity shall have an energy recovery system that is capable of providing a change in the enthalpy or dry-bulb temperature of the outdoor air supply equal to at least 50% of the difference between the outdoor air and return air at design conditions. A heat recovery system bypass shall be provided to permit air economizer operation as required by 780 CMR 1305.3.7.

Exceptions:

1. Laboratory systems meeting 780 CMR 1305.3.13.2.
2. Systems serving spaces which are not cooled and which are heated to less than 60°F.
3. Systems exhausting toxic, flammable, paint exhaust, corrosive fumes, or dust which makes the installation of heat recovery equipment impractical.
4. Commercial kitchen hoods (grease) classified as Type 1 by *NFPA 96*.
5. Where more than 60% of the outdoor heating energy is provided from site-recovered or site solar energy

1305.3.13 Exhaust Hoods:

1305.3.13.1 Kitchen Hoods. Individual kitchen exhaust hoods larger than 5000 cfm shall be provided with make-up air sized for at least 50% of exhaust air volume that is:

(a) heated to no more than 60ºF and

(b) uncooled or cooled without the use of mechanical cooling.

Exceptions:

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

1305.3.13.2 Fume Hoods. Buildings with fume hood systems having a total exhaust rate greater than 15,000 cfm shall include at least one of the following features:

1. Variable air volume hood exhaust and room supply systems capable of reducing exhaust and make-up air volume to 50% or less of design values.
2. Direct make-up (auxiliary) air supply equal to at least 75% of the exhaust rate, heated no warmer than 2°F below room set point, cooled to no cooler than 3ºF above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
3. Heat recovery systems to precondition make-up air from fume hood exhaust in accordance with 1305.3.12 Exhaust Air Heat Recovery, without using any exception.

780 CMR 1306.0 SERVICE WATER HEATING

1306.1 General. 780 CMR 1306.0 covers installation of service hot water piping and controls for service water heating equipment.

1306.2 Temperature Controls. Service water heating equipment shall be provided with controls to allow a set point of 110°F for equipment serving dwelling units and 90°F for equipment serving other occupancies. The outlet temperature of lavatories in public facility restrooms shall be limited to 110°F.

1306.3 Heat Traps. Water heating equipment not supplied with integral heat traps and serving non-circulating systems shall be provided with heat traps on the supply and discharge piping associated with the equipment.

1306.4 Service Hot Water Piping Insulation. Piping on return circulation hot water systems, shall be insulated with 1 inch of insulation having a conductivity not exceeding 0.28 Btu per inch/h * ft^2 *°F. The first eight feet of piping in *nonrecirculating* systems served by equipment without integral heat traps shall be insulated with 1 inch of insulation having a conductivity not exceeding 0.28 Btu per inch/h * ft^2 * °F.

1306.5 Hot Water System Controls. Circulating hot water systems or heat trace shall have automatic time switches that are capable of being set to turn off the system.

1306.6 Swimming Pools:

1306.6.1 Pool Covers. Heated pools shall be equipped with a vapor retardant pool cover on or at the water surface.

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

1306.6.2 Pool Heaters. Pool heaters shall meet the efficiency requirements for boilers. Pool heaters fired by natural gas shall not have continuously burning pilot lights.

1306.6.3 On-off Switch. Pool heaters shall be equipped with a readily accessible on-off switch to allow shutting off the heater without adjusting the thermostat setting.

1306.6.4 Time Switches. Time switches 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.

1306.6.5 Temperature Controls. Heated swimming pools shall be equipped with controls to limit heating water temperatures to not more than 80°F.

Exception. Pools used for therapeutic purposes are exempt when approved by the building official.

1306.7 Space Heating and Water Heating. The use of a gas-fired or oil-fired space heating boiler system to provide the total space heating and water heating for a building is allowed when one of the following conditions is met:

1. The single space heating boiler, or the component of a modular or multiple boiler system that is heating the service water, has a standby loss in Btu/h not exceeding (13.3 x pmd + 400) / n where pmd is the probable maximum demand in gal/h determined in accordance with the procedures described in generally accepted engineering standards and handbooks and n is the fraction of the year when the outdoor daily mean temperature is greater than 64.9°F.

   The standby loss is to be determined for a test period of 24-hour duration while maintaining a boiler water temperature of at least 90°F above ambient, with an ambient temperature between 60°F and 90°F. For a boiler with a modulating burner, this test shall be conducted at the lowest input.
2. It can be demonstrated that the use of a single heat source will provide energy savings compared to separate units.
3. The energy input of the combined boiler and water heater system is less than 150,000 Btu/h.

780 CMR 1307.0 ELECTRIC POWER DISTRIBUTION

1307.1 Scope. Electrical distribution systems shall be designed for the efficient distribution of electrical energy from the service entrance to the points of use.

Exceptions:
1. Buildings in use groups R-3 and R-4 (one-and two-family dwellings).
2. *Emergency power systems.*

1307.2 Electrical Metering. In all multi-family dwellings, each dwelling unit shall be separately metered. Also see 527 CMR 12.00.

Exceptions:
1. Publicly financed housing for the elderly with fuel fired heating systems, with centrally operated air conditioning systems, or without air conditioning systems are exempt from this requirement.
2. Publicly financed housing for the elderly with electric resistance or storage heating systems are exempt from this requirement provided there is informational metering of the individual dwelling units.

1307.3 Voltage Drop:

1307.3.1 Feeders. *Feeder conductors* shall be designed for a maximum *voltage drop* of 2% at the design load calculated in accordance with 2701.0.

1307.3.2 Branch Circuits. *Branch circuit* conductors shall be designed for a maximum *voltage drop* of 3% at the design load calculated in accordance with 2701.0.

1307.4 Transformers. Single-phase and three-phase dry-type and liquid-filled distribution transformers first installed after December 31, 1999 shall be selected based on rating as described in 780 CMR 1307.4.1 and 1307.4.2.

Exceptions:
1. liquid-filled transformers below 10 kVA or dry-type transformers below 15 kVA
2. drive transformers, both AC and DC
3. all rectifier transformers and transformers designed for high harmonics
4. autotransformers
5. non-distribution transformers, such as UPS (Uninterruptible Power Supply) transformers
6. special impedance, regulation, and harmonic transformers
7. sealed and non-ventilated transformers
8. retrofit transformers, machine tool transformers, or welding transformers
9. transformers with tap ranges greater than 15% or frequency other than 60 Hz
10. grounding or testing transformers.

1307.4.1 Liquid Immersed Transformers. Liquid immersed *transformers* shall comply with the minimum efficiencies in Table 1307.4.1 as tested and rated in accordance with the Electric Utility Industry Restructuring Act of November 25, 1997, Section 313. ("NEMA TP1.")

1307.4.2 Low Voltage Dry-type Transformers. Low Voltage Dry-type *transformers* shall comply with the minimum efficiencies in Table 1307.4.2 as tested and rated in accordance with NEMA TP 1.

1307.4.3 Medium Voltage Dry-type Transformers. Medium Voltage Dry-type *transformers* shall have effeciencies not less than the applicable values in Table 1307.4.3 when tested at 50% of the rated output power and at 75° C (Table 1307.4.3 copies Table 4-2 or NEMA TP 1-2002, but adds 3/10 point for each value per M.G.L. c. 25B.)

TABLE 1307.4.1 NEMA CLASS 1 EFFICIENCY LEVELS FOR LIQUID-FILLED DISTRIBUTION TRANSFORMERS

Reference Condition	Temperature		% of Nameplate Load
Load Loss	85°C		50%
No Load Loss	20°C		50%
kVA	Single Phase Efficiency	kVA	Three Phase Efficiency
10	98.3	15	98.0
15	98.5	30	98.3
25	98.7	45	98.5
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

TABLE 1307.4.2 NEMA CLASS 1 EFFICIENCY LEVELS FOR LOW VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

Reference Condition Low Voltage	Temperature 75° C	% of Nameplate Load 35%	
Single Phase Efficiency		Three Phase Efficiency	
kVa	Low Voltage	kVa	Low Voltage
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7
500	--	750	98.8
667	--	1000	98.9
833	--	1500	--
		2000	--
		2500	--

TABLE 1307.4.2 NEMA CLASS 1 EFFICIENCY LEVELS FOR MEDIUM VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

Reference Condition Medium Voltage		Temperature 75°C		% of Nameplate Load 50%	
Single Phase			Three Phase		
Rated power output in kVa	Minimum efficiency %		Rated power output in kVa	Minimum efficiency %	
	≤ 60kV BIL	> 60kV BIL		≤ 60kV BIL	> 60kV BIL
≥15 <25	97.9	97.9	≥15 <30	97.1	97.1
≥25 <37.5	98.2	98.2	≥30 <45	97.6	97.6
≥37.5 <50	98.4	98.4	≥45 <75	97.9	97.9
≥50 <75	98.5	98.5	≥75 <112.5	98.2	98.2
≥75 <100	98.7	98.7	≥112.5 <150	98.4	98.4
≥100 <167	98.8	98.8	≥150 <225	98.5	98.5
≥167 <250	99.1	99	≥225 <300	98.7	98.7
≥250 <333	99.2	99.1	≥300 <500	99.1	98.8
≥333 <500	99.3	99.2	≥500 <750	99.1	99
≥500 <667	99.4	99.3	≥750 <1000	99.2	99.1
≥667 <833	99.5	99.3	≥1000 <1500	99.3	99.2
833	99.5	99.4	≥1500 <2000	99.4	99.3
			≥2000 <2500	99.5	99.3
			2500	99.5	99.4

kVa = kilovolt amperes
kV = kilovolts
BIL = basic impulse insulation level l

780 CMR 1308.0 LIGHTING SYSTEMS

1308.1 General. The lighting criteria in 780 CMR 1308.0 shall apply to lighting for the following:

1. interior spaces of *buildings*;
2. exterior building features, including façades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies; and,
3. exterior building grounds lighting provided through the *building's* electrical *service*.

Exceptions:

1. emergency lighting that is automatically off during normal *building* operation and is powered by battery, generator, or other alternate power source; and,
2. lighting within living units of residential buildings;
3. lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation;
4. decorative gas lighting systems.

1308.2 Lighting Control.

1308.2.1 Automatic Lighting Shutoff. Interior lighting in *buildings* larger than 5000 ft^2 shall be controlled with an *automatic control device* to shut off *building* lighting in all spaces. This *automatic control device* shall function on either:

1. a scheduled basis using a time of day operated control device that turns lighting off at specific programmed times. An independent program schedule shall be provided for areas of no more than 25,000 ft^2 but 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. an unscheduled basis by occupant intervention.

Exceptions:

1. Lighting intended for 24 hour operation shall not require an Automatic Control Device.
2. Automatic Control Devices are not required in the following spaces: corridors, hallways, stairways and lobbies which are part of a required means of egress; restrooms; mechanical rooms, and; electrical rooms. If automatic control devices are used in the spaces listed, they shall not reduce illumination below the levels prescribed in 780 CMR 1024.0 (Means of Egress Lighting.)

1308.2.2 Space Control. Each space enclosed by ceiling-height partitions shall have at least one *control device* to independently *control* the *general lighting* within the space. Each *control device* shall be activated either manually by an occupant or automatically by sensing an occupant. Each *control device* shall.

1. *control* a maximum of 2,500 ft^2 area for a space 10,000 ft^2 or less, and a maximum of 10,000 ft^2 area for a space greater than 10,000 ft^2,
2. be capable of overriding the shutoff *control* required in 780 CMR 1308.2.1 for no more than two hours, and
3. be readily accessible and located so the occupant can see the controlled lighting.

Exceptions:

1. Remote location shall be permitted for reasons of safety or security when the remote control device has an indicator pilot light as part of or next to the control device and it shall be clearly labeled to identify the controlled lighting.
2. Means of egress lighting which provides the minimum illumination identified in 780 CMR 1308.2.1 Exception 2. shall be controlled in accordance with 780 CMR 1024.0.

1308.2.3 Uniform Reduction. Each perimeter office space enclosed by ceiling-height partitions shall have a manual control to allow the occupant to uniformly reduce the connected lighting load by at least 50%

Exception. Spaces with automatic daylighting controls.

1308.2.4 Additional Control.

1. Display/Accent Lighting - display or accent lighting shall have a separate *control device*.
2. Case Lighting - lighting in cases used for display purposes shall be equipped with a separate *control device*.
3. Hotel and Motel Guest Room Lighting - hotel and motel guest rooms and guest suites shall have a master *control device* at the main room entry that *controls* all *permanently installed luminaires* and switched receptacles.
4. Task Lighting - supplemental task lighting including *permanently installed* undershelf or undercabinet lighting shall have a *control device* integral to the *luminaires* or shall be controlled by a wall- mounted *control device* provided the *control device* complies with 1308.2.2.
5. Nonvisual Lighting - lighting for nonvisual applications, such as plant growth and food-warming, shall be equipped with a separate control *device*.
6. Demonstration Lighting - *lighting equipment* that is for sale or for demonstrations in lighting education shall be equipped with a separate *control device*.

1308.2.5 Exterior Lighting Control. Lighting for all exterior applications not exempted in 780 CMR 1308.1 or 1308.7 shall be controlled by a photosensor or astronomical time switch that is

capable of automatically turning off the exterior lighting when sufficient daylight is available or the lighting is not required.

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

1308.3 Tandem Wiring. Luminaires designed for use with one or three linear fluorescent lamps greater than 30 W each shall use two lamp tandem-wired ballasts in place of single lamp ballasts when two or more luminaires are in the same space and on the same control device.

Exceptions:
1. recessed luminaires more than ten ft apart measured center to center,
2. surface mounted or pendant luminaires which are not continuous,
3. luminaires using single lamp high-frequency electronic ballasts,
4. luminaires using three lamp high-frequency electronic ballasts or three lamp electromagnetic ballasts,
5. luminaires on emergency circuits,
6. luminaires with no available pair.

1308.4 Exit Signs. Exit sign *luminaires* operating at greater than 20 watts shall have a minimum source efficacy of 35 lm/W.

1308.5 Exterior Building Grounds Lighting. All exterior building grounds luminaires which operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under 780 CMR 1308.1 or 1308.7.

1308.6 Interior Lighting Power. The *installed interior lighting power* identified in accordance with 780 CMR 1308.6.1 shall not exceed the *interior lighting power allowance* developed in accordance with 780 CMR 1308.6.2.

1308.6.1 Installed Interior Lighting Power. The *installed interior lighting power* shall include the power of all *lighting*. The *installed interior lighting power* includes all power used by the *luminaires*, including *lamps*, *ballasts*, current regulators, and *control devices*.

Exceptions:
1. If two or more independently operating lighting systems in a space are capable of being controlled to prevent simultaneous user operation, the installed interior lighting power shall be based solely on the lighting system with the highest wattage.
2. The following *lighting equipment* and applications shall not be considered when determining the *interior lighting power allowance* developed in accordance with 780 CMR 1308.6.2, nor shall the wattage for such lighting be included in the *installed interior lighting power*. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent *control device*.
   a. Lighting in spaces specifically designed for use by the visually impaired.
   b. See Table 1308.6.2.1, footnote b. and Table 1308.6.2.2, footnotes b. and c. governing lighting for retail displays.
   c. Lighting in interior spaces that have been specifically designated as a registered interior *historic* landmark.
   d. Athletic playing areas with permanently installed lighting for television broadcasting.
   e. Casino gambling areas.
3. The following *lighting equipment* shall not be included in the *installed interior lighting power*. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent *control device*.
   a. Display or accent lighting that is an essential element for the function performed in monuments.
   b. Lighting that is integral to *equipment* or instrumentation and is installed by its *manufacturer.*
   c. Lighting specifically designed for use only during medical or dental procedures and lighting integral to medical *equipment*.
   d. Lighting integral to both open and glass enclosed refrigerator and freezer cases.
   e. Lighting integral to food warming and food preparation *equipment*.
   f. Lighting for plant growth or maintenance.
   g. Lighting that is an integral part of advertising or directional signage.
   h. Exit signs.
   i. Lighting that is for sale or lighting educational demonstration *systems*.
   j. Lighting for theatrical purposes, including, performance, stage, and film and video production.

1308.6.1.1 Luminaire Wattage. Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following criteria: the wattage of incandescent or tungsten-halogen luminaires with medium screw base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaire.

Exceptions:
1. Luminaires for which lower wattage lamps are specified in construction documents, maintenance and operating manuals, and reports specified in 1301.8.4.

2. the wattage of luminaires with permanently installed or remotely installed ballasts shall be the operating input wattage of the specified lamp/ballast combination based on values from manufacturers catalogs or values from independent testing lab reports.

3. the wattage of line voltage lighting track and plug-in busway that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the lower of.

a. the specified wattage of the luminaires included in the system with a minimum of 30 W/lin ft.

b. the specified wattage of the circuit protection device.

4. the wattage of low-voltage lighting track, cable conductor, rail conductor, and other flexible lighting systems that allow for the addition and/or relocation of luminaires without altering the wiring of the system shall be the specified wattage of the transformer supplying the system.

5. the wattage of all other miscellaneous lighting equipment shall be the specified wattage of the equipment.

1308.6.2 Interior Lighting Power Allowance. The *interior lighting power allowance* for a *building* or a separately metered or permitted portion of a *building* shall be determined by either the *building* area method described in 1308.6.2.1 or the Space-by-Space method described in 780 CMR 1308.6.2.2. Trade-offs of *interior lighting power allowance* among portions of the *building* for which a different method of calculation has been used are not permitted.

1308.6.2.1 Building Area Method of Calculating Interior Lighting Power Allowance. The Building Area Method shall be used only in the following cases:

(a) projects involving the entire building, or

(b) projects involving a single, independent, and separate occupancy in a multi-occupancy building.

Use the following steps to determine the interior lighting power allowance by the Building Area Method:

1. Determine the appropriate building type from Table 1308.6.2.1 and the allowed lighting power density (watts/unit area) from the building area method column. For building types not listed, selection of a reasonably equivalent type shall be permitted.

2. Determine the gross lighted floor area (square feet) of the *building*.

3. The *interior lighting power allowance* is the product of the lighted floor area of the *building* times the *lighting power density.*

TABLE 1308.6.2.1 LIGHTING POWER DENSITIES USING THE BUILDING AREA METHOD

Lighting Power Density	
Building Area Type[a]	**(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 Theatre	1.2
Multi-family	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 Buildings	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 foot = 304.8mm, 1 watt per square foot = W/0.0929 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.

b. Where lighting equipment is specified to be installed to highlight specific merchandise 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 merchandise, or 1.6W/ft^2 times the area of the specific display but not to exceed 50% of the floor area, or 3.9 W/ft^2times the actual case or shelf area for displaying and selling jewelry, china or silver, shall be added to the interior lighting power determined in accordance with this line item.

1308.6.2.2 Space-by-Space Method of Calculating Interior Lighting Power Allowance. Use the following steps to determine the interior lighting power allowance by the space-by-space method.

1. For each space enclosed by partitions 80% or greater than ceiling height, determine the gross interior floor area by measuring to the center of the partition wall. Include the floor area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.

2. Determine the *interior lighting power allowance* for each space from Table 1308.6.2.2. Multiply the floor area(s) of the space(s) times the allowed *lighting power density* for the space type that most closely represents the proposed use of the space(s). The product is the *lighting power allowance* for the space(s). For space types not listed, selection of a reasonable equivalent category shall be permitted.

3. The *interior lighting power allowance* is the sum of *lighting power allowances* of all spaces. Trade-offs among spaces are permitted provided that the total *installed interior lighting power* does not exceed the *interior lighting power allowance*.

TABLE 1308.6.2.2 LIGHTING POWER DENSITIES USING THE SPACE-BY-SPACE METHOD

LIGHTING POWER DENSITIES	
Building Type	**LPD (W/ft2)**
Building Specific Space Types[a,b]	
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 hospitals	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 hospitals	1.0
for manufacturing facilities	0.5
Stairs - active	0.6
Active storage	0.8
for hospitals	0.9
Inactive storage	0.3
for museum	0.8
Electrical/mechanical	1.5
Workshop	1.9
Gymnasium/exercise center	
playing area	1.4
exercise Area	0.9
Court House/police station/penitentiary	
courtroom	1.9
confinement cells	0.9
judges chambers	1.3

LIGHTING POWER DENSITIES	
Building Type	**LPD (W/ft2)**
Building Specific Space Types[a,b]	
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 & cataloguing	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	1.9
radiology	0.4
laundry/washing	0.6
Automobile - 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 areas	1.5
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 arena	2.7
court sports arena	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
airport/train/bus – baggage area	1.0
terminal – ticket counter	1.5

a. In cases where both a common space type and a building specific type are listed, the building specific space type shall apply.
b. Where installation of lighting equipment for decorative appearances is specified, in addition to lighting equipment 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 1.0 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 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 1.6W/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 Standard 90.1-2004 Energy Standard for Buildings Except Low-Rise Residential Buildings, 780 CMR 9.00, Table 9.6.1.

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

1308.6.2.3 Additional Interior Lighting (Power-by-Space Method). See Tables 1308.6.2.2, footnotes a., b. and/or c.

1308.7 Exterior Building Lighting Power. The exterior lighting power allowance is the sum of lighting power allowances for all of the applicable exterior applications permitted, other than building façades, provided that the total installed exterior lighting power does not exceed the exterior lighting power allowance. Exterior lighting for all other applications (except those included in the Exceptions to 780 CMR 1308.7) shall comply with the requirements of 780 CMR 1308.5.

TABLE 1308.7 LIGHTING POWER LIMITS 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/ft2
Building Grounds	
Walkways less than 10 feet wide	1.0 watts/linear foot
Walkways 10 feet wide or wider, plaza areas and special feature areas	0.2W/ft2
Stairways	1.0W/ft2
Building Entrances and Exits	
Main entries	30 watts/linear foot of door width
Other doors	20 watts per linear foot of door width
Canopies and Overhangs	
Canopies (free standing and attached and overhangs)	1.25 W/ft2
Outdoor Sales	
Open areas (including vehicle sales lots)	0.5 W/ft2
Street frontage for vehicle sales lots in addition to “open area” allowance	20 watts per 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 allowances otherwise permitted in the “Tradable Surfaces” section of this Table.)	
Building façades	0.2 W/ft2 for each illuminated wall or surface 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/ft2 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/ft2 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

Exceptions. Lighting used for the following exterior applications is exempt when equipped with an independent *control device*:

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.

780 CMR 1309.0 BUILDING DESIGN BY SYSTEMS ANALYSIS

1309.1 General. 780CMR 1309.0 establishes design criteria in terms of total energy use by a building including all of its systems.

A building designed in accordance with 780CMR 1309.0 will be deemed as complying with 780CMR 13.00 if the annual energy consumption is not greater than if the building were designed with enclosure elements and energy consuming systems in compliance with 780CMR 1304.0 through 1308.0.

1309.2 Analysis Procedure. The analysis of the annual energy usage of the standard and the proposed alternative building and system design shall meet the following criteria:

1. Energy Analysis. The calculation procedure used to simulate the operation of the building and its service systems through a full year operating period shall be of sufficient detail to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. The calculation procedure shall be based upon 8760 hours of operation of the building and its service systems and shall utilize techniques recommended in the ASHRAE Handbook, 1997 Fundamentals Volume.
2. Climatic Data. Coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation, in accordance with Tables 1303.1 and 1303.2.
3. Energy Sources. Identical energy sources must serve the same purpose in both the standard and the proposed alternative design. If the proposed alternative design results in an increase in consumption of one energy source and a decrease in another energy source, each energy source shall be converted to equivalent Btu units for purposes of comparing the total energy used. Consumption of electricity shall be converted at the rate of 10,000 Btu/kWh for the purpose of this comparison.
4. Nondepletable Energy Sources. Energy collected on site from nondepletable sources shall be omitted from the comparison of total energy used. Energy collected off site from nondepletable sources shall be included in the comparison of total energy used.
5. Building Operation. Building operation shall be simulated for a full calendar year. Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays, and any seasonal operation. Schedules shall model the time-dependent variations of occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage, and any process loads.

   Exception. Operating schedules shall be permitted to differ between the proposed design and the standard design to allow simulation of the impact of any automatic control provided in the proposed design beyond the minimum requirements in 780 CMR 1304.0 through 1309.0.

6. Simulated Loads. The following systems and loads shall be modeled in determining total building performance. heating systems; cooling systems; fan systems; lighting power; receptacle loads; and process loads that exceed 1.0 watts per square foot of floor area of the room or space in which the process loads are located.

   Exception. Systems required for emergency power only.

7. Service Water Heating Systems. Service water heating systems that are other than combined service hot water/space heating systems shall be permitted to be omitted from the energy analysis provided all requirements of 780 CMR 1306 have been met.
8. Exterior Lighting. Where included in the analysis the exterior lighting systems shall be the same in the standard and proposed designs.

1309.3 Proposed Design. Building systems and loads shall be simulated in the proposed design as follows:

1. HVAC and Service Water Heating Equipment. All HVAC and Service Water Heating Equipment shall be simulated in the proposed design using capacities, rated efficiencies, and part-load performance data for the proposed equipment as provided by the equipment manufacturer.
2. Features Not Documented at Time of Permit. Any feature of the proposed design not included in the construction documents shall be assumed to be

equal to the corresponding feature in the standard design.

3. Mandatory Requirements. The proposed design shall meet the requirements of the following without exception:

a. 780 CMR 1304.1.2 Moisture Control
b. 780 CMR 1304.2.7 Slabs on Grade
c. 780 CMR 1304.2.8 Slabs Below Grade
d. 780 CMR 1304.3 Air Leakage
e. 780 CMR 1304.4 Insulation General
f. 780 CMR 1305.3.4 Temperature and Humidity Controls
g. 780 CMR 1305.3.8 & .9 Distribution System Construction and Insulation
h. 780 CMR 1307.0 ELECTRIC POWER DISTRIBUTION
i. 780 CMR 1308.2 Lighting Control

1309.4 Standard Design. The standard design, conforming to the criteria of 780 CMR 1309, and the proposed design, shall be designed on a common basis as specified herein. The comparison shall be expressed as Btu input per square foot of gross floor area per year.

The heating and cooling system zoning, orientation of each building feature, number of floors, and the gross envelope areas of the standard design shall be the same as those of the proposed design.

Exception. Permanent fixed or movable external shading devices for windows and glazed doors shall be excluded from the standard design.

1309.5 Documentation. Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis comparison report prepared by a professional registered engineer or registered architect. The report shall provide sufficient technical detail on the two buildings and systems designs, and on the data used in and resulting from the comparative analysis, to verify that both the analysis and the designs meet the criteria of 780 CMR 13.00. The documentation shall demonstrate that the analysis used is consistent with ASHRAE calculation procedures and accepted engineering practice.

Exception. Proposed alternative designs for buildings having an area of 5,000 square feet or less and having the indoor temperature controlled from a single point are exempted from the full year energy analysis as described in 780 CMR 1309.2. A comparison of energy consumption between the alternative design and the standard design shall be provided in a report prepared by a registered professional engineer or architect. Such analysis shall follow the bin or degree day methods or other simplified analysis procedures in ASHRAE 1997 Handbook of Fundamentals.

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