Northwest Power and Conservation Council

October 4, 2006

DECISION MEMORANDUM

TO: Council Members

FROM: Charlie Grist

SUBJECT: Implementation of Model Conservation Standards for New Commercial Buildings

PROPOSED ACTION: Release for comment the attached specifications that would implement the Model Conservation Standards (MCS) for new commercial buildings adopted in the Fifth Power Plan.

SIGNIFICANCE: The Council would be following through with its intent in the Fifth Power Plan to consult with the interested parties in the region on the detailed provisions of the MCS for new commercial buildings. This is part of the implementation of the Fifth Power Plan as called for in actions CNSV-1 and CNSV-6.

BUDGETARY/ECONOMIC IMPACTS: Staff anticipates two days of staff time to collate and review comments with the technical working group that developed the specifications.

BACKGROUND: The Act requires the Council to adopt model conservation standards (MCS) as part of each power plan. In Appendix F of the Fifth Power Plan, the Council set out the model standard for new commercial buildings. That standard is described conceptually as the better of ASHRAE 90.1-2001 or the most efficient provisions of existing commercial building energy standards promulgated by the states of Idaho, Montana, Oregon and Washington.[1] The underlying rationale of this MCS is that each of the existing codes used in the region contains some leading-edge elements and some that could be improved. A consolidation of the best elements of ASHRAE and each jurisdiction's code yields a model standard better than any of the existing codes. Furthermore, since each of the codes from which provisions would be drawn are

[1] New commercial buildings and existing commercial buildings that undergo major remodels or renovations are to be constructed to capture savings equivalent to those achievable through constructing buildings to the better of 1) . . . ASHRAE Standard 90.1-2001 . . . and addenda a through [m] or . . . 2) the most efficient provisions of existing commercial building energy standards promulgated by the states of Idaho, Montana, Oregon and Washington so long as those provisions reflect geographic and climatic differences within the region, other appropriate considerations, and are designed to produce power savings that are cost-effective for the region and economically feasible for [consumers] taking into account financial assistance made available from Bonneville. Fifth Power Plan, Appendix F, page F-8

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already adopted, they meet one of the Regional Act requirements for MCS, that the model standard be economically feasible for consumers. The Fifth Power Plan also said that the Council would assist in determining which specific provisions of existing codes make up the non-residential MCS.

If adopted by the Council as implementation of the MCS for new commercial buildings, the proposed specifications would be helpful in ongoing local code adoption processes. The Council would also be following through with its intent in the Fifth Power Plan to consult with regional parties to determine the specific provisions of the MCS for new commercial buildings.

ANALYSIS: Since the adoption of the Fifth Power Plan, the region has undertaken a project to determine specific provisions from among ASHRAE Standard 90.1-2001 and the region's adopted codes that comprise requirements that produce the greatest measure of cost-effective savings in commercial buildings. The development of the code-type language and the selection of specific provisions were conducted by a contractor and have been has reviewed for stringency, clarity and ability to be implemented by a volunteer technical advisory group of regional experts from all four states. Hundreds of code provisions were reviewed, discussed and debated. These provisions have been melded into a single document and formatted in the style of the International Energy Efficiency Code (IECC) used by the majority of state code jurisdictions in the region. This allows the provisions to be easily incorporated into state or local codes by jurisdictional code agencies if they so choose.

Releasing the proposed specifications for a 20-day comment period would allow the Council to evaluate opinions on the specific provisions before considering them for adoption at its November meeting. Because of the conceptual nature of the MCS adopted in the Fifth Power Plan, it would be prudent to allow for comment on the detailed specifications proposed.

ALTERNATIVE: The Council could adopt the specifications without public comment. The specifications were developed by a team of regional experts from all the states, and as such already incorporate a significant amount of consultation.

ATTACHMENTS:
1) *Proposed Specifications for Implementation of Fifth Power Plan Model Conservation Standards for New Non-Residential Buildings.*
2) *Summary of Components of the "Best of the Region" Standard for New Non-Residential Buildings.* This document contains a summary of code provisions and identification of the source code for each of the selected of code provisions.

Proposed Specifications for Implementation of Fifth Power Plan Model Conservation Standards for New Commercial Buildings

October 13, 2006

Overview

The Northwest Power and Conservation Council seeks comment on the attached specifications that it proposes to use to implement the Model Conservation Standards for new commercial buildings adopted in the Fifth Northwest Electric Power and Conservation Plan.

Description. The proposed specifications are a compilation of the best provisions of energy codes from ASHRAE[1] Standard 90.1-2001 and the existing codes adopted by states or local jurisdictions in the Pacific Northwest. These provisions are designed to capture the most stringent energy provisions for each component of the code and reflect geographic and climatic differences within the region, other appropriate considerations, and are designed to produce power savings that are cost-effective for the region and economically feasible for consumers taking into account financial assistance made available from Bonneville.

Development of the Specifications. Input into the development of these specifications was provided by a technical working group in an effort to provide a consensus approach to determining the best elements of existing energy codes. To develop this standard, a contractor, Ecotope, reviewed the most widely enforced regional codes to develop a composite document that includes the best standard for each component. The codes consulted including the Washington and Oregon state energy codes, the Seattle Energy Code, the International Energy and Conservation Code adopted in the states of Idaho and Montana and the ASHRAE Standard 90.1-2001.

The contractor and the technical working group considered several factors in determining which provisions from ASHRAE and the codes of the Northwest states to select for the specifications. The recommendations and alterations agreed to by the technical working group have been included in the specifications. The measure of cost-effective savings in commercial buildings was the most important factor for inclusion. Both efficiency level and breadth of scope were considered. But for some elements of the specifications, the clarity of the language or ease of implementation was favored over energy savings. ASHRAE was used for equipment efficiency levels that fall under federal jurisdiction. In addition, some ASHRAE provisions have been adopted by the states and therefore appear in the specifications.

The improvements made by compiling this set of specifications are significant but modest. About one-third of the provisions evaluated are identical among the states so there is no effective change in efficiency levels between existing state standards and the composite model standard. In the lighting provisions, compiling the most stringent lighting power density requirements from existing codes results in modest (5 to 30 percent) reductions of maximum allowed connected lighting power for some occupancy categories in some jurisdictions. But for the most common occupancy categories, differences are zero or relatively small. Perhaps more importantly, the number of occupancy categories in the

[1] ASHRAE is the American Society of Heating Refrigeration and Air-Conditioning Engineers.

lighting tables is reduced thus simplifying the specifications. For mechanical provisions the compilation of the best provisions results in changes that primarily extend the scope of existing efficiency or control provisions to more systems or buildings. The same is true for lighting controls provisions. With regard to envelope insulation levels, Washington standards are generally the most stringent and form the bulk of the specifications. For glazing the Oregon and Seattle standards prevail. For the performance path, Washington's standard with Seattle amendments is the model provision. In addition, the many different climate zone definitions used in ASHRAE, IECC and the state codes were simplified to a two-zone system.

The accompanying document, *Summary of Components of the "Best of the Region" Standard for New Non-Residential Buildings*, summarizes the MCS specifications for new commercial buildings and identifies the source code for each. The specifications are in the format of the International Energy and Conservation Code (IECC) including the same chapter and section numbers, organization, and much of the same administrative language. Thus, the core of the specifications appears in Chapter 8. Chapters 1, 2 and 3 are included because they contain definitions relied on in Chapter 8. Because the IECC format was used, some of the definitions in Chapters 1, 2, and 3 refer to residential buildings.

Cost-Effectiveness and Economic Feasibility. The Council believes that the compiled provisions meet the cost-effectiveness and economic feasibility standards set forth in the in the Regional Act[2]. With regard to cost-effectiveness to the power system, the substantive provisions in the attached specifications form the baseline against which energy efficiency opportunities in the Fifth Northwest Electric Power and Conservation Plan are compared. In the power plan, the Council analyzes many measures beyond the most stringent of the existing codes and finds them cost-effective to the power system. Since measures beyond the baseline are cost-effective to the power system, the Council believes measures less efficient are cost-effective as well. For example, the power plan finds that lighting power densities 10 to 15 percent lower than those in the specifications are cost-effective to the power system.

With regard to economic feasibility to the consumer, the Council believes existing code provisions easily meet the Council's test of economic feasibility to the consumer. Energy codes represent the minimum efficiency level that it is legal to build. Due to the nature of the adoption processes in the states; energy codes represent minimum levels of efficiency that are perceived as practicable. The stringency and practicability of codes for commercial buildings are largely determined by professional consensus among practitioners participating in local code adoption processes. While states differ on whether and how they apply economic feasibility tests to the codes they adopt, the Council maintains that any economic feasibility test applied by the states directly or implicitly is more difficult to meet than that the life-cycle-cost methodology that the Council uses. Detailed life-cycle-cost analyses of the economic feasibility of these specifications, which are derived from codes already in place in the states, would be expensive and not informative.

[2] The Act requires that the Council's Model Conservation Standards be cost-effective to the power system and economically feasible for consumers taking into account any financial assistance made available through Bonneville and the region's utilities. The Council's test for cost-effectiveness to the power system is explained in the Fifth Northwest Electric Power and Conservation Plan, Appendix E. The Council's test for economic feasibility has historically been based on a life-cycle cost of owning and operating a building or a home.

Comments: The Council seeks comment on these specifications. In particular, the Council is interested in whether the provisions selected represent the most efficient provisions with clear language that can be implemented through the building and code compliance processes.

Please submit comments by close of business November 7, 2006 to:

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CHAPTER 1 ADMINISTRATION AND ENFORCEMENT

SECTION 101
SCOPE AND GENERAL REQUIREMENTS

101.1 Title. This standard shall be known as the *Best of the Region Energy Standards*, and shall be cited as such or as *Northwest Baseline Standar*d. It is referred to herein as "this standard."

101.2 Scope. This standard applies to residential and commercial buildings.

> **Exception:** Existing buildings undergoing repair, or change of occupancy except as noted in section 101.4.3. This standard applies to buildings undergoing substantial remodeling or rehabilitation that would be regulated under the provisions for new buildings in an existing energy code in accordance with Section 101.4.2.

101.3 Intent. This standard shall provide guidance for the design and construction of buildings for the effective use of energy. This standard is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve the effective use of energy. This standard is not intended to abridge safety, health or environmental requirements contained in other applicable standards, codes or ordinances.

101.4 Applicability.

101.4.1 Historic buildings. For any building or structure that is listed in the State or National Register of Historic Places; designated as a historic property under local or state designation law or survey; certified as a contributing resource with a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the National or State Registers of Historic Places either individually or as a contributing building to a historic district by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, the specific requirements of this standard may be modified for historic buildings and require in lieu thereof alternate requirements which will result in a comparable degree of energy efficiency.

101.4.2 Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to an existing building, building system or portion thereof will be considered to conform to the provisions of this standard as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply with this standard.

> **Exceptions:** The following need not comply provided the energy use of the building is not increased.
>
> 1. Storm windows installed over existing fenestration.
> 2. Glass only replacements in an existing sash and frame.
> 3. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.
> 4. Construction where the existing roof, wall or floor cavity is not exposed.

101.4.3 Change in occupancy. This standard shall be applicable to buildings undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy.

101.4.4 Mixed occupancy. Where a building includes both residential and commercial occupancies, each occupancy shall be separately considered and meet the applicable provisions of Chapters 4 and 5 for residential and Chapter 8 for commercial.

101.5 Compliance. Residential buildings shall meet the provisions of Chapter 4. Commercial buildings shall meet the provisions of Chapter 8.

101.5.1 Compliance materials. Compliance with this standard shall be documented using computer software, worksheets, compliance manuals and other similar materials that meet the intent of this standard. The plans and specifications shall show in sufficient detail all pertinent data and features of the building and the equipment and systems.

101.5.2 Unconditioned buildings. Unconditioned buildings are defined as those that do not contain conditioned space, or unconditioned spaces, separated from the remainder of the building by building thermal envelope assemblies complying with this standard. Unconditioned buildings and spaces shall be exempt from the building thermal envelope provisions of this standard.

SECTION 102
MATERIALS, SYSTEMS AND EQUIPMENT

102.1 Identification. Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this standard.

102.1.1 Building thermal envelope insulation. An R-value identification mark shall be applied by the manufacturer to each piece of building thermal envelope insulation 12 inches (305 mm) or greater in width. Alternately, the insulation installers shall provide a certification listing the type, manufacturer and R-value of insulation installed in each element of the building thermal envelope. For blown or sprayed insulation (fiberglass and cellulose), the initial installed thickness, settled thickness, settled *R*-value, installed density, coverage area and number of bags installed shall be listed on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness, the areas covered and R-value of the installed thickness shall be listed on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

102.1.1.1 (Supp) Blown or sprayed roof/ceiling insulation. The thickness of blown in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed at least one for every 300 ft^2 (28 m^2) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed R-value shall be listed on certification provided by the insulation installer.

102.1.2 Insulation mark installation. Insulating materials shall be installed such that the manufacturer's R-value mark is readily observable.

102.1.3 Fenestration product rating. U-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100 by an accredited, independent laboratory, and labeled and certified by the manufacturer.

102.2 Installation. All materials, systems and equipment shall be installed in accordance with the manufacturer's installation instructions and the locally enforced energy code.

102.2.1 Protection of exposed foundation insulation. Insulation applied to the exterior of basement walls, crawlspace walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend a minimum of 6 inches (153 mm) below grade.

102.3 Maintenance information. Maintenance instructions shall be furnished for equipment and systems that require preventive maintenance. Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

102.4 Default building component performance values. Values in shown in Chapter 5 may be used to assess performance of building components. The applicability of these values to the building and construction details proposed shall be in accordance with local energy code guidelines.

SECTION 103
ALTERNATE MATERIALS METHOD OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS

103.1 General. This standard is not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system meets the intent of this standard, defined as any such alternate provided it meets or exceeds the provisions of this standard and that the material, method, design or work offered is for the purpose intended, at least the equivalent of that prescribed in this standard in quality, strength, effectiveness, fire-resistance, durability, safety and the efficient use and conservation of energy.

SECTION 104
REFERENCED STANDARDS

104.1 General. The standards, and portions thereof, referred to in this standard and listed in Chapter 5 shall be considered part of the requirements of this standard to the extent of such reference.

104.2 Conflicting requirements. The provisions of this standard shall take precedence where the provisions of this standard and the referenced standards conflict.

CHAPTER 2 DEFINITIONS

GENERAL

201.1 Scope. Unless stated otherwise, the following words and terms in this standard shall have the meanings indicated in this chapter.

SECTION 201

201.2 Interchangeability. Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural includes the singular.

201.3 Terms defined in other codes. Terms that are not defined in this standard but are defined in the *International Building Code, ICC Electrical Code, International Fire Code, International Fuel Gas Code, International Mechanical Code, International Plumbing Code,* or the *International Residential Code* shall have the meanings ascribed to them in those codes.

201.4 Terms not defined. Terms not defined by this chapter shall have ordinarily accepted meanings such as the context implies.

SECTION 202
GENERAL DEFINITIONS

ABOVE GRADE WALL. A wall more than 50 percent above grade and enclosing conditioned space. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof, and skylight shafts.

ACCESSIBLE. Admitting close approach as a result of not being guarded by locked doors, elevation or other effective means (see "Readily accessible").

ADDITION. An extension or increase in the conditioned space floor area or height of a building or structure.

ALTERATION. Any construction or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a mechanical system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit.

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").

BASEMENT WALL. A wall 50 percent or more below grade and enclosing conditioned space.

BUILDING. Any structure used or intended for supporting or sheltering any use or occupancy.

BUILDING THERMAL ENVELOPE. The basement walls, exterior walls, floor, roof, and any other building element that enclose conditioned space. This boundary also includes the boundary between conditioned space and any exempt or unconditioned space.

COMMERCIAL BUILDING. For this standard, all buildings that are not included in the definition of Residential Buildings.

COMPLIANCE APPROACH: The methods available for demonstrating compliance with the provisions of this standard. Three paths are available:

- **Prescriptive Standard**: Individual building components comply with the provisions described in Sections 402 and 403. Each component must meet the performance standard as written.
- **Component Performance Standard**: Individual building components can be traded-off against each other to achieve an overall heat loss equal to or better than the performance that would be achieved using the Prescriptive Standard. Only building components used in calculating the overall building heat loss rate (UA) as defined in Section 402.1 can be considered.
- **Systems Analysis Standard**: Individual building components are combined to develop a performance standard which includes all HVAC and building shell requirements. Compliance is demonstrated to be equal to or better than the performance that would be achieved by the Prescriptive Standard using an energy simulation tool.

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the conditioned space.

CONDITIONED SPACE. An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent conditioned space.

CRAWLSPACE WALL. The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

CURTAIN WALL. Fenestration products used to create an external non-load bearing wall that is designed to separate the exterior and interior environments.

DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

DWELLING UNIT. A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

ECONOMIZER, AIR. A duct and damper arrangement and automatic control system that 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 where 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.

ENERGY ANALYSIS. A method for estimating the annual energy use of the proposed design and standard reference design based on estimates of energy use.

ENERGY RECOVERY VENTILATION SYSTEM. Systems that employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of preheating, precooling, humidifying or dehumidifying outdoor ventilation air prior to supplying the air to a space, either directly or as part of an HVAC system.

ENERGY SIMULATION TOOL. An approved software program or calculation-based methodology that projects the annual energy use of a building.

EXTERIOR WALL. Walls enclosing conditioned space, including both above grade walls and basement walls, which are vertical or sloped at an angle 60 degrees or greater from horizontal.

ENTRANCE DOOR. Fenestration products used for ingress, egress and access in non-residential buildings, including, but not limited to, exterior entrances that utilize latching hardware, automatic closers and contain over 50% glass specifically designed to withstand heavy use and possibly abuse.

FACTORY-ASSEMBLED GLAZED FENESTRATION PRODUCT. Fenestration products that are shipped to the field as factory-assembled units comprised of specified frame and glazing components including operable and fixed windows, and skylights.

FENESTRATION. Skylights, roof windows, vertical windows (fixed or moveable), opaque doors, glazed doors, glazed block, and combination opaque/glazed doors. Fenestration includes products with glass and nonglass glazing materials.

HEAT RECOVERY VENTILATOR (HRV). A ventilation device designed to provide outdoor air for ventilation while recovering energy by heat exchange from the exhaust airstream.

HEAT TRAP. An arrangement of piping and fittings, such as elbows, or a commercially available heat trap that prevents thermosyphoning of hot water during standby periods.

HEATED SLAB. Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under the slab.

HUMIDISTAT. A regulatory device, actuated by changes in humidity, used for automatic control of relative humidity.

INFILTRATION. The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

INSULATING SHEATHING. An insulating board with a core material having a minimum R-value of R-2.

LABELED. Devices, equipment, or materials to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-labeled items that attests to compliance with a specific standard.

LISTED. Equipment, appliances, assemblies or materials included in a list published by an approved testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment, appliances, assemblies or material, and

whose listing states either that the equipment, appliances, assemblies, or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

LOW-VOLTAGE LIGHTING. Lighting equipment powered through a transformer such as a cable conductor, a rail conductor and track lighting.

MANUAL. Capable of being operated by personal intervention (see "Automatic")

PROPOSED DESIGN. A description of the proposed building used to estimate annual energy use for determining compliance based on total building performance.

READILY ACCESSIBLE. Capable of being reached quickly for operation, renewal or inspection 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").

REPAIR. The reconstruction or renewal of any part of an existing building.

RESIDENTIAL BUILDING. For this standard, includes R-3 buildings, as well as R-2 and R-4 buildings.

R-VALUE (THERMAL RESISTANCE). The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area (°*F-hr/Btu).*

ROOF ASSEMBLY. A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly includes the roof covering, underlayment, roof deck, insulation, vapor retarder and interior finish.

SCREW LAMP HOLDERS. A lamp base that requires a screw-in-type lamp, such as a compact-fluorescent, incandescent, or tungsten-halogen bulb.

SERVICE WATER HEATING. Supply of hot water for purposes other than comfort heating.

SITE-BUILT GLAZED PRODUCT. Fenestration products that are designed to be field glazed or field assembled units comprised of specified frame and glazing components including operable and fixed windows, curtain walls, window walls, storefronts, sloped glazing and skylights.

SKYLIGHT. Glass or other transparent or translucent glazing material installed at a slope of 15 degrees (0.26 rad) or more from vertical. Glazing material in skylights, including unit skylights, solariums, sunrooms, roofs and sloped walls is included in this definition. (see "Glazing area").

SOLAR HEAT GAIN COEFFICIENT (SHGC). The ratio of the solar heat gain entering the space through the fenestration assembly 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.

STANDARD REFERENCE DESIGN. A version of the proposed design that meets the minimum requirements of this standard and is used to determine the maximum annual energy use requirement for compliance based on total building performance.

STOREFRONT. A non-residential system of doors and windows mulled as a composite fenestration structure that has been designed to resist heavy use and possible abuse and provide a high level of resistance to wind load and impact from wind borne debris. Storefront systems include, but are not limited to, exterior fenestration systems that span from the floor level or above to the ceiling of the same story on commercial buildings.

SUNROOM. A one-story structure attached to a dwelling with a glazing area in excess of 40 percent of the gross area of the structure's exterior walls and roof.

THERMAL ISOLATION. Physical and space conditioning separation from conditioned space(s). The conditioned space(s) shall be controlled as separate zones for heating and cooling or conditioned by separate equipment.

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

U-FACTOR (THERMAL TRANSMITTANCE). The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/hr-°*F*).

VAPOR RETARDER. A vapor resistant material, membrane or covering such as foil, plastic sheeting, or insulation facing having a permeance rating of 1 perm or less when tested in accordance with the desiccant method using Procedure A of ASTM E 96.

Vapor retarders limit the amount of moisture vapor that passes through a material or wall assembly.

VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

VENTILATION AIR. That portion of supply air that comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

ZONE. A space or group of spaces within a building with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device.

CHAPTER 3 CLIMATE ZONES

SECTION 301 CLIMATE ZONES

301.1 General. Climate zones from Table 301.1 shall be used in determining the applicable requirements from Chapters 4 and 8 for the Pacific Northwest region.

SECTION 302 DESIGN CONDITIONS

302.1 Interior design conditions. The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling.

TABLE 301.1
CLIMATE ZONES BY STATE AND COUNTY

Washington	Zone 1 - Rest of State Zone 2 - Ferry County Okanogan County Pend Oreille County Stevens County
Oregon	Zone 1 - All of State
Idaho	Zone 1 - Ada County Benewah County Canyon County Cassia County Elmore County Gooding County Jerome County Kootenai County Latah County Lewis County Lincoln County Minidoka County Nez Perce County Owyhee County Payette County Twin Falls County Washington County Zone 2 - Rest of State
Montana	Zone 2 - All of State

CHAPTER 8
NON-RESIDENTIAL ENERGY EFFICIENCY

SECTION 801
SCOPE AND GENERAL REQUIREMENTS

801.1 Scope. The requirements contained in this chapter are applicable to non-residential buildings, or portions of non-residential buildings.

801.2 (Supp) General. Walls, roof assemblies, floors, glazing and slabs on grade which are part of the building envelope for buildings where the window and glazed door area is not greater than 50 percent of the gross area of above-grade walls shall meet the requirements of Sections 802.2.1 through 802.2.7, as applicable. Buildings with more glazing shall meet the applicable provisions of ASHRAE/IESNA 90.1.

801.3 Application. The requirements in Sections 802 (Building envelope), 803 (Building mechanical systems), 804 (Service water heating) and 805 (Lighting) shall each be satisfied on an individual basis.

> **Exception:** Buildings conforming to Section 806, provided Sections 802.4, 802.5, 803.2, 804, 805.1, 805.2, 805.3, 805.4, 805.6 and 805.7 are each satisfied.

SECTION 802 BUILDING ENVELOPE REQUIREMENTS

802.1 General

802.1.1 Insulation and fenestration criteria. The building thermal envelope shall meet the requirements of Tables 802.2 and 802.3 based on the climate zone specified in Chapter 3. Buildings with a vertical fenestration area or skylight area that exceeds that allowed in Table 802.2 shall comply with the building envelope provisions of ASHRAE/IESNA 90.1.

802.2 Specific insulation requirements. Opaque assemblies shall comply with Table 802.2.

802.2.1 Roof assembly. The minimum thermal resistance (R-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table 802.2, based on construction materials used in the roof assembly.

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

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

802.2.2 Classification of walls. Walls associated with the building envelope shall be classified in accordance with Section 802.2.2.1 or 802.2.2.2.

802.2.2.1 Above-grade walls. Above-grade walls are those walls covered by Section 802.2.3 on the exterior of the building and completely above grade or walls that are more than 15 percent above grade.

802.2.2.2 Below-grade walls. Below-grade walls covered by Section 802.2.4 are basement or first-story walls associated with the exterior of the building that are at least 85 percent below grade.

802.2.3 Above-grade walls. The minimum thermal resistance (R-value) of the insulating material(s) installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table 802.2, based on framing type and construction materials used in the wall assembly. The R-value of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table 802.2. "Mass walls" shall include walls weighing at least (1) 35 pounds per square foot (170 kg/m^2) of wall surface area or (2) 25 pounds per square foot (120 kg/m^2) of wall surface area if the material weight is not more than 120 pounds per cubic foot (1,900 kg/m^3).

802.2.4 Below-grade walls. The minimum thermal resistance (R-value) of the insulating material installed in, or continuously on, the below-grade walls shall be as specified in Table 802.2, and shall extend to a depth of 10 feet (3048 mm) below the outside finish ground level, or to the level of the floor, whichever is less.

802.2.5 Floors over outdoor air or unconditioned space. The minimum thermal resistance (R-value) of the insulating material installed either between the

floor framing or continuously on the floor assembly shall be as specified in Table 802.2, based on construction materials used in the floor assembly.

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

802.2.6 Slabs on grade. The minimum thermal resistance (R-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors shall be as specified in Table 802.2. The insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table.

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

802.3 Fenestration. Fenestration shall comply with Table 802.2.

802.3.1 Maximum area. The vertical fenestration area (not including opaque doors) shall not exceed the percentage of the gross wall area specified in Table 802.2. The skylight area shall not exceed the percentage of the gross roof area specified in Table 802.2.

802.3.2 Maximum U-factor and SHGC. For vertical fenestration, the maximum U-factor and solar heat gain coefficient (SHGC) shall be as specified in Table 802.2, based on the window projection factor. For skylights, the maximum U-factor and solar heat gain coefficient (SHGC) shall be as specified in Table 802.2.

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

(Equation 8-1)

PF = A/B
where:

PF=Projection factor (decimal).

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

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

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

802.4 Air leakage

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

> **Exception:** Site-constructed windows and doors that are weatherstripped or sealed in accordance with Section 802.4.3.

802.4.2 Curtain wall, storefront glazing and commercial entrance doors. Curtain wall, storefront glazing and commercial-glazed swinging entrance doors and revolving doors shall be tested for air leakage at 1.57 pounds per square foot (psf) (75 Pa) in accordance with ASTM E 283. For curtain walls and storefront glazing, the maximum air leakage rate shall be 0.3 cubic feet per minute per square foot (cfm/ft^2) (5.5 $m^3/h \times m^2$) of fenestration area. For commercial glazed swinging entrance doors and revolving doors, the maximum air leakage rate shall be 1.00 cfm/ft^2 (18.3 $m^3/h \times m^2$) of door area when tested in accordance with ASTM E 283.

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

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

> **Exception:** Gravity (non-motorized) dampers are permitted to be used in buildings less than three stories in height above grade.

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

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

> **Exceptions:**
> 1. Buildings in Climate Zones 1 and 2 as indicated in and Table 301.1.
> 2. Doors not intended to be used as a building entrance door, such as doors to mechanical or electrical equipment rooms.
> 3. Doors opening directly from a guestroom or dwelling unit.
> 4. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area.
> 5. Revolving doors.
> 6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

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

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

802.5 Moisture control. All framed walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 1 perm (5.7 x 10^{-11} kg/Pa · s · m^2) or less, when tested in accordance with the desiccant method using Procedure A of ASTM E 96. The vapor retarder shall be installed on the warm-in-winter side of the insulation.

> **Exceptions:**
> 1. Buildings located in Climate Zones 1 through 3 as indicated in Table 301.1.
> 2. In construction where moisture or its freezing will not damage the materials.
> 3. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.

Table 802.2 Building Envelope Requirements

	Climate Zone 1	Climate Zone 2
Roofs		
Maximum U-factor requirement,	U=.036	U=0.033
Insulation entirely above deck	R-20 ci	R-25 ci
Metal buildings (with R-5 thermal blocks[1])[2]	R-30	R-30
Attic and all below deck insulation	R-30	R-38
Walls, Above Grade		
Maximum U-factor requirement,	U=0.062	U=0.062
Mass (added insulation value)	R-15, U=0.07	R-15, U=0.07
CMU	R-15, U=0.07	R-15, U=0.07
Metal building[2]	R-19+ R-13	R-19+ R-13
Metal framed	R-19+R-3.8 ci	R-19+R-3.8 ci
Wood framed and other	R-19	R-19
Walls, Below Grade		
Maximum U-factor (not including ground buffering effects)	U=.065	U=.065
Below grade wall[4]	R-19	R-19
Floors		
Maximum U-factor requirement (not including buffering effects of adjacent spaces)	U=0.045	U=0.035
Mass[5]	R-10 ci, U=0.09	R-10 ci, U=0.09
Joist/Framing	R-19	R-30
Slab-on-Grade Floors		
Perimeter F-value (Unheated Slabs)	F=0.54	F=0.54
Unheated Slabs[5]	R-10 for 24 In. below	R-10 for 24 In. below
Heated Slabs[5]	R-10ci below	R-10ci below
Opaque Doors		
Swinging	Hinged <4' wide U=0.6 , all other U=0.2	Hinged <4' wide U=0.6 , all other U=0.2
Roll-up or sliding	U=0.6 coil roll up/ U=0.2 other	U=0.6 coil roll up/ U=0.2 other
Windows		
Non-metal Frames	U0.35/SHGC 0.4	U0.35/SHGC 0.4
Metal Frames[6]		
0%-25%	U0.54/SHGC 0.4	U0.50/SHGC 0.4
25%-30%	U0.54/SHGC 0.4	U0.37/SHGC 0.4
30%-35%	U0.37/SHGC 0.4	U0.37/SHGC 0.4
35%-40%	U0.37/SHGC 0.4	Not allowed.
> 40%	Not allowed.	Not allowed.
Skylights[7]		
<3%	U0.6/SHGC 0.4	U0.6/SHGC 0.4

1.Thermal blocks are a minimum R-5 of rigid insulation, which extends 1" beyond the width of the purtin on each side, perpendicular to the purtin.
2. Assembly descriptions can be found in Table 802.2(3)
3. R-5.7 ci may be substituted with concrete block walls complying with A5TM C90, ungrouted or partially grouted at 32 in. or less on center vertically and 48 in. or less on center horizontally, with ungrouted cores filled with material having a maximum thermal conductivity of 0.44 8tu-in.lh-f2 F.
4. When heated slabs are placed below grade, below grade walls must meet the exterior insulation requirements for perimeter insulation according to the heated slab-on-grade construction.
5. All slabs shall include and R-5 thermal break between the slab edge and the outside or between the slab and the structural concrete.
6. Percent of gross exterior wall area allowed in glazing. Includes entire rough opening of window systems.
7. Percent of roof area allowed in skylight glazing. Includes entire rough opening of skylight systems

SECTION 803
BUILDING MECHANICAL SYSTEMS

803.1 General. Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Section 803.2 (referred to as the mandatory provisions) and either:

1. Section 803.3 (Simple systems), or
2. Section 803.4 (Complex systems).

803.2 Provisions applicable to all Mechanical systems.

803.2.1 Calculation of heating and cooling loads. Design loads shall be determined in accordance with the procedures described in the ASHRAE Fundamentals Handbook. Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE HVAC Systems and Equipment Handbook. Alternatively, design loads shall be determined by an approved equivalent computation procedure, using the design parameters specified in Chapter 3.

803.2.1.1 Equipment and system sizing. Heating and cooling equipment and systems capacity shall not exceed the loads calculated in accordance with Section 803.2.1. A single piece of equipment providing both heating and cooling must satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

Exceptions:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.

803.2.2 Packaged Electric Heating and Cooling Equipment. If packaged HVAC systems providing both heating and cooling with electric energy and have a total cooling capacity greater than 20,000 Btu/h then the heating equipment shall be a heat pump.

Exception:

Unstaffed equipment shelters or cabinets used solely for personal wireless service facilities.

803.2.3 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables 803.2.3(1), 803.2.3(2), 803.2.3(3), 803.2.3(4), 803.2.3(5), 803.2.3(6), 803.2.3(7), 803.2.3(8), 803.2.3(9), 803.2.3(10) and 803.2.3(11) when tested and rated in accordance with the applicable test procedure. The efficiency shall be verified through certification under an approved certification program or, if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

Exception:

Equipment listed in Table 803.3.2(7) not designed for operation at ARI Standard test conditions of 44°F (7°C) leaving chilled water temperature and 85°F (29°C) entering condenser water temperature shall have a minimum full load COP and IPLV rating as shown in Tables 803.3.2(8) through 803.3.2(10) as applicable. The table values are only applicable over the following full load design ranges:

Leaving Chilled Water Temperature: 40 to 48°F (4 to 9°C)
Entering Condenser Water Temperature: 75 to 85°F (24 to 29°C)
Condensing Water Temperature Rise: 5 to 15°F (3 to 8°C)

Chillers designed to operate outside of these ranges shall comply with Section 803.4.

Gas-fired and oil-fired forced air furnaces with input ratings ≥ 225,000 Btu/h (65 kW) shall also have an intermittent ignition or interrupted device (IID), and have either mechanical draft (including power venting) or a flue damper. A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings ≥ 225,000 Btu/h

(65 kW), including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75% of the input rating.

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

803.2.5 HVAC system controls. Each heating and cooling system shall be provided with thermostatic controls as required in Sections 803.2.4.1 through 803.2.4.5.

803.2.5.1 Thermostatic controls. The supply of heating and cooling energy to each zone shall be controlled by individual thermostatic controls capable of responding to temperature within the zone. At a minimum, each floor of a building shall be considered as a separate zone.

Where humidification or dehumidification or both is provided, at least one humidity control device shall be provided for each humidity control system.

> **Exception:** Independent perimeter systems that are designed to offset only building envelope heat losses or gains or both serving one or more perimeter zones also served by an interior system provided:
>
> 1. The perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one orientation (within +/- 45 degrees) (0.8 rad) for more than 50 contiguous feet (15.2 m); and,
> 2. The perimeter system heating and cooling supply is controlled by a thermostat(s) located within the zone(s) served by the system.

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

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

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

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

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

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

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

803.2.5.6 Shutoff dampers. Both outdoor air supply and exhaust ducts shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use or during building warm-up, cool-down, and setback.

> **Exceptions:**
> 1. Gravity dampers shall be permitted in buildings less than three stories in height
> 2. Systems serving areas which require continuous operation.
> 3. Combustion air intakes.
> 4. Gravity (non-motorized) dampers are acceptable in exhaust and relief outlets in the first story and levels below the first story of buildings three or more stories in height.
> 5. Type 1 Grease hoods exhaust.

Stair and shaft vents shall be capable of being automatically closed during normal building operation and are interlocked to open as required by fire and smoke detection systems.

Dampers installed to comply with this section, including dampers integral to HVAC equipment, shall have a maximum leakage rate when tested in accordance with AMCA Standard 500 of:

a. Motorized dampers in package HVAC: 10 cfm/ft2 of damper area at 1.0 in. w.g.
b. All other motorized dampers: 4 cfm/ft2 of damper area at 1.0 in. w.g.
c. Non-motorized dampers: 20 cfm/ft2 of damper area at 1.0 in. w.g., except that for non-motorized dampers smaller than 24 inches in either dimension: 40 cfm/ft2 of damper area at 1.0 in. w.g.

Dampers used as a component of packaged HVAC equipment shall comply with the damper leakage requirements.

803.2.5.7 Optimum start controls. Separate HVAC systems with a design supply air capacity exceeding 10,000 cfm (4,720 L/s) shall have controls that are capable of automatically varying start-up time of system to just meet temperature set point at time of occupancy. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint and the amount of time prior to scheduled occupancy.

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

803.2.6.1 Ventilation Controls for High-Occupancy Areas (Demand Ventilation Controls). The following systems shall incorporate means to automatically reduce outside air intake below design rates when spaces are unoccupied or partially occupied (demand ventilation controls):

a. Single-zone systems where all of the following criteria are met:

    1. an air economizer is installed, and
    2. design outside airflow is greater than 1,200 cfm, and
    3. design occupancy of the spaces served by the system is greater than 40 people per 1,000 ft^2 of floor area.

b. All other single-zone where both of the following criteria are met:

    1. design outside airflow is greater than 3,000 cfm, and
    2. large rooms served by multiple systems with a combined ventilation air capacity of 1,500 CFM and an occupant load factor of 20 or less must also meet this requirement.

c. Multiple-zone where both of the following criteria are met:

    1. design outside airflow is greater than 3,000 cfm, and
    2. design occupancy of the spaces served by the system is greater than 100 people per 1,000 ft2 of floor area.

CO^2 sensors shall be located between one foot and six feet above the floor. Ventilation controls shall be in compliance with ASHRAE Standard 62.

Demand ventilation controls shall maintain CO^2 concentrations less than or equal to 600 ppm plus the outdoor air CO^2 concentration in all rooms with CO^2 sensors.

Exception: The outdoor air ventilation rate is not required to be larger than the design outdoor air ventilation rate required by the ASHRAE standard 62 regardless of CO^2 concentration.

The outdoor air CO^2 concentration shall be assumed to be 400 ppm without any direct measurement or the CO^2 concentration shall be dynamically measured using a CO^2 sensor located near the position of the outdoor air intake.

When the system is operating during hours of expected occupancy, the controls shall maintain system outdoor air ventilation rates no less than 5 percent of total system airflow.

CO^2 sensors shall be certified by the manufacturer to have an accuracy of no less than 75 ppm, factory calibrated or calibrated at start-up, and certified by the manufacturer to require calibration no more frequently than once every 5 years.

803.2.6.2 Enclosed Parking Garage Ventilation. Garage ventilation fan systems with a total design capacity greater than 30,000 cfm shall include the equipment specified in (a) and (b) below. Smaller systems shall include the equipment specified in either (a) or (b).

d. An automatic control that is capable of staging fans or modulating fan volume as required to maintain carbon monoxide (CO) concentration below a level of 50 ppm as stated in ASHRAE Standard 62. This provision only applies to garages used predominantly by gasoline or diesel powered vehicles.
e. An automatic control that is capable of shutting off fans or reducing fan volume during periods when the garage is not in use. The system shall be equipped with at least one of the following:

    i. An automatic timeclock that can start and stop the system under different schedules for seven different day-types per week, is capable of retaining programming and time setting during loss of power for a period of at least 10 hours, and includes an accessible manual override that allows temporary operation of the system for up to 2 hours.
    ii. An occupant sensor.

803.2.6.3 Energy recovery ventilation systems. Individual fan systems that have both a design supply air capacity of 5,000 cfm (2.36 m^3/s) or greater and a minimum outside air supply of 70 percent or greater of the design supply air quantity shall have an energy recovery system that provides a change in the enthalpy of the outdoor air supply of 50 percent or more of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the energy recovery system to permit cooling with outdoor air where cooling with outdoor air is required. Laboratory fume hoods must comply with section 803.2.10.2.

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

1. Where energy recovery systems are prohibited by the *International Mechanical Code*.
2. Systems serving spaces that are not cooled and are heated to less than 60°F (15.5°C).
3. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
4. Cooling systems in climates with a 1 percent cooling design wet-bulb temperature less than 64 °F (17.7°C).
5. Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil.

803.2.7 Duct and plenum insulation and sealing. All supply and return air ducts and plenums shall be insulated in accordance with Table 803.2.7.

Exceptions:
1. When located within equipment.
2. When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (Δ8°C)

All joints, longitudinal and transverse seams and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes.

803.2.7.1 Rigid fibrous glass ducts. Closure systems used to seal rigid fibrous glass duct joints shall comply with UL 181 A and shall be marked "181 A-P" for pressure-sensitive tape, "181 A-M" for mastic or "181 A-H" for heat-sensitive tape.

803.2.7.2 Flexible air ducts. Closure systems used to seal flexible air duct joints and flexible air connector joints shall comply with UL 181B and shall be marked "181 B-FX" for tape or "181 B-M" for mastic. Tape shall be a minimum of 12 mil (0.38 mm) total thickness, and shall be permitted to be cloth backed.

803.2.7.3 Metal to metal ducts. Closure systems used to seal metal to metal duct joints shall comply with UL 181B and shall be marked "181 B-FX" for tape or "181 B-M" for mastic. Tape shall be a minimum of 12 mil (0.38 mm) total thickness, and shall include butyl rubber adhesive/sealant. Joints of metal to metal duct systems and their components shall not be sealed with cloth backed tapes.

Unlisted duct tape is not permitted as a sealant on any duct.

Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Crimp joints for round ducts shall have a contact lap of at least 1.5 inches (38 mm) and shall be mechanically fastened by means of at least three sheet metal screws or rivets equally spaced around the joint. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened per the manufacturers' installation instructions.

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

803.2.7.4.1 Low and Medium pressure duct systems. All ducts and plenums designed to operate at a static pressure less than or equal to 3 inches w.g. (750 Pa) shall be insulated and sealed in accordance with Section 803.2.8. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code.*

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

803.2.7.4.2 High-pressure duct systems. Ducts designed to operate at static pressures in excess of 3 inches w.g. (746 Pa) shall be insulated and sealed in accordance with Section 803.2.7. In addition, ducts and plenums shall be leak-tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual* with the rate of air leakage (*CL*) less than or equal to 6.0 as determined in accordance with Equation 8-2.

(Equation 8-2)

$$CL = F \times P^{0.65}$$

Where:
F =The measured leakage rate in cfm per 100square feet of duct surface.
P=The static pressure of the test.

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

803.2.8 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 803.2.8.

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

803.2.9 HVAC system completion. Prior to the issuance of a certificate of occupancy, the design professional shall provide evidence of system completion in accordance with Sections 803.2.9.1 through 803.2.9.3.

803.2.9.1 Air system balancing. Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *International Mechanical Code*. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 25 hp (18.6 kW) and larger.

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

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

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

803.2.9.4 Systems Commissioning

803.2.9.4.1 Simple Systems: For simple systems and for warehouses and semi-heated spaces, HVAC control systems shall be tested to ensure that control devices, components, equipment and systems are calibrated, adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to ensure they operate in accordance with approved plans and specifications. A complete report of test procedures and results shall be prepared and filed with the owner. Drawing notes shall require commissioning in accordance with this paragraph.

803.2.9.4.2 Other Systems: All other HVAC control systems, and other automatically controlled systems for which energy consumption, performance, or mode of operation are regulated by this code, shall be tested to ensure that control devices, equipment and systems are calibrated, adjusted and operate in accord with approved plans and specifications. Sequences of operation shall be functionally tested to ensure they operate in accord with approved plans and specifications.

803.2.9.4.3 Documentation: Drawing notes shall require commissioning in accordance with this section. Drawing notes may refer to specifications for further commissioning requirements. Plans and specifications shall require tests mandated by this section be performed and the results recorded. Plans and specifications shall require preparation of preliminary and final reports of test procedures and results as described in Section 803.2.9.4.3.1. Plans and specifications shall identify the following for each test:

1. Equipment and systems to be tested, including the extent of sampling tests,
2. Functions to be tested (for example, calibration, economizer control, etc.),
3. Conditions under which the test shall be performed (for example, winter design conditions, full outside air, etc.),
4. Measurable criteria for acceptable performance.

803.2.9.4.3.1 Commissioning Reports

803.2.9.4.3.1.1 Preliminary Commissioning Report: A preliminary commissioning report of test procedures and results shall be prepared. The preliminary report shall identify:

1. Deficiencies found during testing required by this section which have not been corrected at the time of report preparation and the anticipated date of correction.
2. Deferred tests which cannot be performed at the time of report preparation due to climatic conditions.
3. Climatic conditions required for performance of the deferred tests, and the anticipated date of each deferred test.

803.2.9.4.3.1.2 Final Commissioning Report: A complete report of test procedures and results shall be prepared and filed with the owner.

803.2.9.4.3.1.3 Acceptance: Buildings or portions thereof, required by this code to comply with this section, shall not be issued a final certificate of occupancy until such time that the building official determines that the preliminary commissioning report required by this section has been completed

803.2.10 Exhaust Hoods

803.2.10.1 Kitchen Hoods. Individual kitchen exhaust hoods larger than 5000 cfm shall be provided with make-up air sized so that at least 50% of exhaust air volume be (a) unheated or heated to no more than 60ºF and (b) uncooled or cooled air 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.

803.2.10.2 Fume Hoods. Each fume hood in 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 by 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 2ºF 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 in accordance with Section 803.2.6.3, without using any exception.

4. Constant volume fume hood designed and installed to operate at less than 50 fpm face velocity.

TABLE 803.2.3(1) UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS also includes TABLE 803.2.3(6) CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air Conditioners, Air Cooled	<65,000 Btu/h[c]	All	Split System	13.0 SEER	ARI 210/240
			Single Package	13.0 SEER	
Through-the-Wall, Air Cooled	≤ 30,000 Btu/h[c]	All	Split System	10.9 SEER, 12 SEER (as of 1/23/ 2010)	
			Single Package	10.6 SEER, 12.0 SEER (as of 1/23/2010)	
Small-Duct High-Velocity, Air Cooled	< 65,000 Btu/h[c]	All	Split System	10 SEER	
Air Conditioners, Air Cooled	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System / Single Package	11.0 EER 11.4IPLV	ARI 340/360
		All other	Split System / Single Package	11.0 EER 11.4IPLV	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System / Single Package	10.8 EER 11.2IPLV	
		All other	Split System/ Single Package	10.8 EER 11.2IPLV	
	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance (or None)	Split System / Single Package	10.0 EER 10.4IPLV	
		All other	Split System / Single Package	10.0 EER 10.4IPLV	
	≥760,000 Btu/h	Electric Resistance (or None)	Split System / Single Package	10.0 EER 10.4IPLV	
		All other	Split System / Single Package	10.0 EER / 10.4IPLV	
Air Conditioners, Water and Evaporatively Cooled	<65,000 Btu/h	All	Split System / Single Package	14.0 EER	ARI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System / Single Package	14.0 EER	ARI 340/360
		All other	Split System \ Single Package	14.0 EER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System \ Single Package	14.0 EER	
		All other	Split System \ Single Package	14.0 EER	
	≥240,000 Btu/h	Electric Resistance (or None)	Split System \ Single Package	14.0 EER	
		All other	Split System \ Single Package	14.0 EER	

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
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	

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

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

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

TABLE 803.2.3(2)
UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air Cooled (Cooling Mode)	<65,000 Btu/h[c]	All	Split System	13.0 SEER	ARI 210/240
			Single Package	13.0 SEER	
Through-the-Wall, Air Cooled, Cooling Mode	≤ 30,000 Btu/h[c]	All	Split System	10.9 SEER, 12 SEER (as of 1/23/ 2010)	
			Single Package	10.6 SEER, 12.0 SEER (as of 1/23/2010)	
Small-Duct High-Velocity, Air Cooled, Cooling Mode	< 65,000 Btu/h[c]	All	Split System	10 SEER	
Air Cooled (Cooling Mode)	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER, 11.4IPLV	ARI 340/360
		All other	Split System and Single Package	11.0 EER, 11.4IPLV	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	,10.8 EER, 11.2 IPLV	
		All other	Split System and Single Package	10.8 EER, 11.2 IPLV	
	≥240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER, 10.4 IPLV	
		All other	Split System and Single Package	10.0 EER, 10.4 IPLV	
Water-Source (Cooling Mode)	<17,000 Btu/h	All	86ºF Entering Water	14.0 EER	ISO-13256-1
	≥17,000 Btu/h and <65,000 Btu/h	All	86ºF Entering Water	14.0 EER	ISO-13256-1
	≥65,000 Btu/h and <135,000 Btu/h	All	86°F Entering Water	14.0 EER	ISO-13256-1
Groundwater-Source (Cooling Mode)	<135,000 Btu/h	All	59°F Entering Water	16.2 EER	ISO-13256-1
Ground Source (Cooling Mode)	<135,000 Btu/h	All	77°F Entering Water	13.4 EER	ISO-13256-1
Air Cooled (Heating Mode)	<65,000 Btu/hc(Cooling Cap.)	–	Split System	8.0HSPF	ARI 210/240
			Single Package	7.5 HSPF	
Through-the-Wall, (Air	≤30,000 Btu/hc (cooling cap.)	-	Split System	7.1 HSPF, after 1/23/2010 7.4 HSPF	

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Cooled, Heating Mode)			Single Package	7.0 HSPF, after 1/23/2010 7.4 HSPF	
Small-Duct High-Velocity (Air Cooled, Heating Mode)	< 65,000 Btu/hc (cooling cap.)	-	Split System	6.8 HSPF	
Air Cooled (Heating Mode)	≥65,000 Btu/h and <135,000 Btu/h (Cooling Cap.)	–	47°F db/43°F wb Outdoor air	3.4 COP	ARI 340/360
			17°F db/15°F wb Outdoor air	2.4 COP	
	≥135,000 Btu/h (Cooling Cap.)	–	47°F db/43°F wb Outdoor air	3.3 COP	
			17°F db/15°F wb Outdoor air	2.2 COP	
Water-Source (Heating Mode)	<135,000 Btu/h (Cooling Cap.)	–	68°F Entering Water	4.6 COP	ISO-13256-1
Groundwater-Source (Heating Mode)	<135,000 Btu/h (Cooling Cap.)	–	50°F Entering Water	3.6 COP	ISO-13256-1
Ground Source (Heating Mode)	<135,000 Btu/h (Cooling Cap.)	–	32°F Entering Water	3.1 COP	ISO-13256-1

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

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

[c] Single-phase, air-cooled heat pumps < 65,000 Btu/h are regulated by NAECA. SEER and HSPF values are those set by NAECA.

TABLE 803.2.3(3)
PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS; Single-Package Vertical Air Conditioners, Single -Package Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure [a]
PTAC (Cooling Mode) New Construction	All Capacities	95°F db Outdoor air	12.5 – (0.213 × Cap/1000)cEER	ARI 310/380
PTAC (Cooling Mode) Replacementsb	All Capacities	95°F db Outdoor air	10.9 – (0.213 × Cap/1000)cEER	
PTHP (Cooling Mode) New Construction	All Capacities	95°F db Outdoor air	12.3 – (0.213 × Cap/1000)cEER	
PTHP (Cooling Mode) Replacementsb	All Capacities	95°F db Outdoor air	10.8 – (0.213 × Cap/1000)c EER	
PTHP (Heating Mode) New Construction	All Capacities		3.2 – (0.026 × Cap/1000)cCOP	
PTHP (Heating Mode) Replacementsb	All Capacities		2.9 – (0.026 × Cap/1000)cCOP	
SPVAC (Cooling Mode)	All Capacities	95°F db/ 75°F wb Outdoor air	8.6 EER	ARI 390
SPVHP (Cooling Mode)	All Capacities	95°F db/ 75°F wb Outdoor air	8.6. EER	
SPVHP (Heating Mode)	All Capacities	47°F db/ 43°F wb Outdoor air	2.7 COP	
Room Air Conditioners, with Louvered Sides	<6000 Btu/h		9.7 SEER	ANSI/ AHAM RAC-1
	≥6000 Btu/h and <8000 Btu/h		9.7 EER	
	≥8000 Btu/h and <14,000 Btu/h		9.8 EER	
	≥14,000 Btu/h and <20,000 Btu/h		9.7 SEER	
	≥20,000 Btu/h		8.5 EER	
Room Air Conditioners, Without Louvered Sides	<8000 Btu/h		9.0 EER	
	≥8000 Btu/h and <20,000 Btu/h		8.5 EER	
	≥20,000 Btu/h		8.5 EER	
Room Air Conditioner Heat Pumps with Louvered Sides	<20,000 Btu/h		9.0 EER	
	≥20,000 Btu/h		8.5 EER	
Room Air Conditioner Heat Pumps without Louvered Sides	<14,000 Btu/h		8.5 EER	
	≥14,000 Btu/h		8.0 EER	
Room Air Conditioner, Casement Only	All Capacities		8.7 EER	
Room Air Conditioner, Casement–Slider	All Capacities		9.5 EER	

[a] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] 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 in. high and less than 42 in. wide.
[c] Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

TABLE 803.2.3(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)	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Warm Air Furnace, Gas-Fired	<225,000 Btu/h		78% AFUE or 80% *Et* [d]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥225,000 Btu/h	Maximum Capacity[d]	80% Ec [c]	ANSI Z21.47
Warm Air Furnace, Oil-Fired	<225,000 Btu/h		78% AFUE or 80% *Et* [d]	DOE 10 CFR Part 430 or UL 727
	≥225,000 Btu/h	Maximum Capacity[e]	81% *Et* [f]	UL 727
Warm Air Furnaces, Electric	All Capacities	Maximum Capacity[e]	100% *Ec* [c]	
Warm Air Duct Furnaces, Gas- Fired	All Capacities	Maximum Capacity[e]	80% *Ec* [g]	ANSI Z83.9
Warm Air Unit Heaters, Gas-Fired	All Capacities	Maximum Capacity[e]	80% *Ec* [g]	ANSI Z83.8
Warm Air Unit Heaters, Oil-Fired	All Capacities	Maximum Capacity[e]	80% Ec g	UL 731

[a] Et= thermal *efficiency*. See test procedure for detailed discussion.
[b] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[c] *Ec* = combustion *efficiency*. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[d] Combination units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating.
[e] Minimum and maximum ratings as provided for and allowed by the unit's controls.
[f] *Et* = thermal *efficiency*. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[g] *Ec* = combustion *efficiency* (100% less flue losses). See test procedure for detailed discussion.

TABLE 803.2.3(5)
BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Typea	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency[b]	Test Procedure[c]
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	Maximum Capacity[d]	75% *E*t [b]	H.I. Htg Boiler Std.
	>2,500,000 Btu/ha	Hot Water	80% *E*[c]	
	>2,500,000 Btu/ha	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	Maximum Capacity[d]	78% *E*t [b]	H.I. Htg Boiler Std.
	>2,500,000 Btu/ha	Hot Water	83% *E*[c]	
	>2,500,000 Btu/ha	Steam	83% *E*[c]	
Oil-Fired (Residual)	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity[d]	78% *E*t [b]	H.I. Htg Boiler Std.
	>2,500,000 Btu/ha	Hot Water	83% *E*[c]	
	>2,500,000 Btu/ha	Steam	83% *E*[c]	

[a] 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.

[b] *Et* = thermal *efficiency*. See reference document for detailed information.

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

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

TABLE 803.2.3(7)
WATER CHILLING PACKAGES, MINIMUM
EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air Cooled, with Condenser, Electrically Operated	All Capacities		2.80 COP 3.05 IPLV	ARI 550/590
Air Cooled, without Condenser, Electrically Operated	All Capacities		3.10 COP 3.45 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities		4.20 COP 5.05 IPLV	ARI 550/590
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	<150 tons		4.45 COP 5.20 IPLV	ARI 550/590
	≥150 tons and <300 tons		4.90 COP 5.60 IPLV	
	≥300 tons		5.50 COP 6.15 IPLV	
Water Cooled, Electrically Operated, Centrifugal	<150 tons		5.00 COP 5.25 IPLV	ARI 550/590
	≥150 tons and <300 tons		5.55 COP 5.90 IPLV	
	≥300 tons		6.10 COP 6.40 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	

[a] The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is <40°F.
[b] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

TABLE 803.2.3(8)
COPs AND IPLVs FOR NONSTANDARD CENTRIFUGAL CHILLERS < 150 TONS

Centrifugal Chillers < 150 tons COP_{std}= 5.00; $IPLV_{std}$= 5.25														
			Condenser Flow Rate											
Leaving Chilled Water Temperature (°F)	**Entering Condenser Water Temperature (°F)**	**LIFT[a]** (°F)	**2 gpm/ton**		**2.5 gpm/ton**		**3 gpm/ton**		**4 gpm/ton**		**5 gpm/ton**		**6 gpm/ton**	
			COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]
40	75	35	5.11	5.35	5.33	5.58	5.48	5.73	5.67	5.93	5.79	6.06	5.88	6.15
40	80	40	4.62	4.83	4.92	5.14	5.09	5.32	5.27	5.52	5.38	5.63	5.45	5.70
40	85	45	3.84	4.01	4.32	4.52	4.58	4.79	4.84	5.06	4.98	5.20	5.06	5.29
41	75	34	5.19	5.43	5.41	5.66	5.56	5.81	5.75	6.02	5.89	6.16	5.99	6.26
41	80	39	4.73	4.95	5.01	5.24	5.17	5.41	5.35	5.60	5.46	5.71	5.53	5.78
41	85	44	4.02	4.21	4.46	4.67	4.70	4.91	4.94	5.17	5.06	5.30	5.14	5.38
42	75	33	5.27	5.51	5.49	5.74	5.64	5.90	5.85	6.12	6.00	6.27	6.11	6.39
42	80	38	4.84	5.06	5.10	5.33	5.25	5.49	5.43	5.67	5.53	5.79	5.61	5.87
42	85	43	4.19	4.38	4.59	4.80	4.81	5.03	5.03	5.26	5.15	5.38	5.22	5.46
43	75	32	5.35	5.59	5.57	5.82	5.72	5.99	5.95	6.23	6.11	6.39	6.23	6.52
43	80	37	4.94	5.16	5.18	5.42	5.32	5.57	5.50	5.76	5.62	5.87	5.70	5.96
43	85	42	4.35	4.55	4.71	4.93	4.91	5.13	5.12	5.35	5.23	5.47	5.30	5.54
44	75	31	5.42	5.67	5.65	5.91	5.82	6.08	6.07	6.34	6.24	6.53	6.37	6.67
44	80	36	5.03	5.26	5.26	5.50	5.40	5.65	5.58	5.84	5.70	5.96	5.79	6.05
44	85	41	4.49	4.69	4.82	5.04	5.00	5.25	5.20	5.43	5.30	5.55	5.38	5.62
45	75	30	5.50	5.75	5.74	6.00	5.92	6.19	6.19	6.47	6.38	6.68	6.53	6.83
45	80	35	5.11	5.35	5.33	5.58	5.48	5.73	5.67	5.93	5.79	6.06	5.88	6.15
45	85	40	4.62	4.83	4.92	5.14	5.09	5.32	5.27	5.52	5.38	5.63	5.45	5.70
46	75	29	5.58	5.84	5.83	6.10	6.03	6.30	6.32	6.61	6.54	6.84	6.70	7.00
46	80	34	5.19	5.43	5.41	5.66	5.56	5.81	5.75	6.02	5.89	6.16	5.99	6.26
46	85	39	4.73	4.95	5.01	5.24	5.17	5.41	5.35	5.60	5.46	5.71	5.53	5.78
47	75	28	5.66	5.92	5.93	6.20	6.15	6.43	6.47	6.77	6.71	7.02	6.88	7.20
47	80	33	5.27	5.51	5.49	5.74	5.64	5.90	5.85	6.12	6.00	6.27	6.11	6.39
47	85	38	4.84	5.06	5.10	5.33	5.25	5.49	5.43	5.67	5.53	5.79	5.61	5.87
48	75	27	5.75	6.02	6.04	6.32	6.28	6.56	6.64	6.94	6.89	7.21	7.09	7.41
48	80	32	5.35	5.59	5.57	5.82	5.72	5.99	5.95	6.23	6.11	6.39	6.23	6.52
48	85	37	4.94	5.16	5.18	5.42	5.32	5.57	5.50	5.76	5.62	5.87	5.70	5.96
Condenser DT[b]	**14.04**	**11.23**	**9.36**	**7.02**	**5.62**	**4.68**			**5.50**	**5.76**	**5.62**	**5.87**	**5.70**	**5.96**

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature

[b] Condenser DT = Leaving Condenser Water Temperature (°F) – Entering Condenser Water Temperature (°F)

[c] All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature
which is IPLV
Kadj = 6.1507 - 0.30244(X) + 0.0062692(X)2 - 0.000045595(X)3 where X = Condenser DT + LIFT
COPadj = Kadj * COPstd

TABLE 803.2.3(9)
COPs AND IPLV FOR NONSTANDARD CENTRIFUGAL CHILLERS
≥ 150 TONS, ≤ 300 TONS

Centrifugal Chillers ≥150 tons, ≤300 tons COP_{std}= 5.55; $IPLV_{std}$= 5.90														
			Condenser Flow Rate											
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
			COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]
40	75	35	5.65	6.03	5.90	6.29	6.05	6.46	6.26	6.68	6.40	6.83	6.51	6.94
40	80	40	5.10	5.44	5.44	5.80	5.62	6.00	5.83	6.22	5.95	6.35	6.03	6.43
40	85	45	4.24	4.52	4.77	5.09	5.06	5.40	5.35	5.71	5.50	5.87	5.59	5.97
41	75	34	5.74	6.13	5.80	6.38	6.14	6.55	6.36	6.79	6.51	6.95	6.62	7.06
41	80	39	5.23	5.58	5.54	5.91	5.71	6.10	5.91	6.31	6.03	6.44	6.11	6.52
41	85	44	4.45	4.74	4.93	5.26	5.19	5.54	5.46	5.82	5.60	5.97	5.69	6.07
42	75	33	5.83	6.22	6.07	6.47	6.23	6.65	6.47	6.90	6.63	7.07	6.75	7.20
42	80	38	5.35	5.71	5.64	6.01	5.80	6.19	6.00	6.40	6.12	6.53	6.20	6.62
42	85	43	4.63	4.94	5.08	5.41	5.31	5.67	5.56	5.93	5.69	6.07	5.77	6.16
43	75	32	5.91	6.31	6.15	6.56	6.33	6.75	6.58	7.02	6.76	7.21	6.89	7.35
43	80	37	5.46	5.82	5.73	6.11	5.89	6.28	6.08	6.49	6.21	6.62	6.30	6.72
43	85	42	4.81	5.13	5.21	5.55	5.42	5.79	5.66	6.03	5.78	6.16	5.86	6.25
44	75	31	6.00	6.40	6.24	6.66	6.43	6.86	6.71	7.15	6.90	7.36	7.05	7.52
44	80	36	5.56	5.93	5.81	6.20	5.97	6.37	6.17	6.58	6.30	6.72	6.40	6.82
44	85	41	4.96	5.29	5.33	5.68	5.55	5.90	5.74	6.13	5.86	6.26	5.94	6.34
45	75	30	6.08	6.49	6.34	6.76	6.54	6.98	6.84	7.30	7.06	7.53	7.22	7.70
45	80	35	5.65	6.03	5.90	6.29	6.05	6.46	6.26	6.68	6.40	6.83	6.51	6.94
45	85	40	5.10	5.44	5.44	5.80	5.62	6.00	5.83	6.22	5.95	6.35	6.03	6.43
46	75	29	6.17	6.58	6.44	6.87	6.66	7.11	6.99	7.46	7.23	7.71	7.40	7.90
46	80	34	5.74	6.13	5.80	6.38	6.14	6.55	6.36	6.79	6.51	6.95	6.62	7.06
46	85	39	5.23	5.58	5.54	5.91	5.71	6.10	5.91	6.31	6.03	6.44	6.11	6.52
47	75	28	6.26	6.68	6.56	6.99	6.79	7.24	7.16	7.63	7.42	7.91	7.61	8.11
47	80	33	5.83	6.21	6.07	6.47	6.23	6.64	6.47	6.90	6.63	7.07	6.75	7.20
47	85	38	5.35	5.70	5.64	6.01	5.80	6.19	6.00	6.40	6.12	6.52	6.20	6.61
48	75	27	6.36	6.78	6.68	7.12	6.94	7.40	7.34	7.82	7.62	8.13	7.83	8.35
48	80	32	5.91	6.30	6.15	6.56	6.33	6.75	6.58	7.02	6.76	7.21	6.89	7.35
48	85	37	5.46	5.82	5.73	6.10	5.89	6.28	6.08	6.49	6.21	6.62	6.30	6.71
Condenser DT[b]					14.04		11.23		9.36		7.02		5.62	

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature

[b] Condenser DT = Leaving Condenser Water Temperature (°F) – Entering Condenser Water Temperature (°F)

[c] All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature
which is IPLV
Kadj = 6.1507 - 0.30244(X) + 0.0062692(X)2 - 0.000045595(X)3
where X = Condenser DT + LIFT
COPadj = Kadj * COPst

TABLE 803.2.3(10)
COPs AND IPLVs FOR NONSTANDARD CENTRIFUGAL CHILLERS > 300 TONS

Centrifugal Chillers > 300 Tons COP_{std}= 6.10; $IPLV_{std}$= 6.40														
			Condenser Flow Rate											
Leaving Chilled Water Temperature (°F)	**Entering Condenser Water Temperature (°F)**	**LIFT[a]** (°F)	**2 gpm/ton**		**2.5 gpm/ton**		**3 gpm/ton**		**4 gpm/ton**		**5 gpm/ton**		**6 gpm/ton**	
			COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]	COP	NPLV[C]
40	75	35	6.23	6.55	6.50	6.83	6.68	7.01	6.91	7.26	7.06	7.42	7.17	7.54
40	80	40	5.63	5.91	6.00	6.30	6.20	6.52	6.43	6.76	6.56	6.89	6.65	6.98
40	85	45	4.68	4.91	5.26	5.53	5.58	5.86	5.90	6.20	6.07	6.37	6.17	6.48
41	75	34	6.33	6.65	6.60	6.93	6.77	7.12	7.02	7.37	7.18	7.55	7.30	7.67
41	80	39	5.77	6.06	6.11	6.42	6.30	6.62	6.52	6.85	6.65	6.99	6.74	7.08
41	85	44	4.90	5.15	5.44	5.71	5.72	6.01	6.02	6.33	6.17	6.49	6.27	6.59
42	75	33	6.43	6.75	6.69	7.03	6.87	7.22	7.13	7.49	7.31	7.68	7.44	7.82
42	80	38	5.90	6.20	6.21	6.53	6.40	6.72	6.61	6.95	6.75	7.09	6.84	7.19
42	85	43	5.11	5.37	5.60	5.88	5.86	6.16	6.13	6.44	6.28	6.59	6.37	6.69
43	75	32	6.52	6.85	6.79	7.13	6.98	7.33	7.26	7.63	7.45	7.83	7.60	7.98
43	80	37	6.02	6.32	6.31	6.63	6.49	6.82	6.71	7.05	6.85	7.19	6.94	7.30
43	85	42	5.30	5.57	5.74	6.03	5.98	6.28	6.24	6.55	6.37	6.70	6.46	6.79
44	75	31	6.61	6.95	6.89	7.23	7.09	7.45	7.40	7.77	7.61	8.00	7.77	8.16
44	80	36	6.13	6.44	6.41	6.73	6.58	6.92	6.81	7.15	6.95	7.30	7.05	7.41
44	85	41	5.47	5.75	5.87	6.17	6.10	6.40	6.33	6.66	6.47	6.79	6.55	6.89
45	75	30	6.71	7.05	6.99	7.35	7.21	7.58	7.55	7.93	7.78	8.18	7.96	8.36
45	80	35	6.23	6.55	6.50	6.83	6.68	7.01	6.91	7.26	7.06	7.42	7.17	7.54
45	85	40	5.63	5.91	6.00	6.30	6.20	6.52	6.43	6.76	6.56	6.89	6.65	6.98
46	75	29	6.80	7.15	7.11	7.47	7.35	7.72	7.71	8.10	7.97	8.37	8.16	8.58
46	80	34	6.33	6.65	6.60	6.93	6.77	7.12	7.02	7.37	7.18	7.55	7.30	7.67
46	85	39	5.77	6.06	6.11	6.42	6.30	6.62	6.52	6.85	6.65	6.99	6.74	7.08
47	75	28	6.91	7.26	7.23	7.60	7.49	7.87	7.89	8.29	8.18	8.59	8.39	8.82
47	80	33	6.43	6.75	6.69	7.03	6.87	7.22	7.13	7.49	7.31	7.68	7.44	7.82
47	85	38	5.90	6.20	6.21	6.53	6.40	6.72	6.61	6.95	6.75	7.09	6.84	7.19
48	75	27	7.01	7.37	7.36	7.74	7.65	8.04	8.09	8.50	8.41	8.83	8.64	9.08
48	80	32	6.52	6.85	6.79	7.13	6.98	7.33	7.26	7.63	7.45	7.83	7.60	7.98
48	85	37	6.02	6.32	6.31	6.63	6.49	6.82	6.71	7.05	6.85	7.19	6.94	7.30
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature

[b] Condenser DT = Leaving Condenser Water Temperature (°F) – Entering Condenser Water Temperature (°F)

[c] All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature
which is IPLV
Kadj = 6.1507 - 0.30244(X) + 0.0062692(X)2 - 0.000045595(X)3
where X = Condenser DT + LIFT
COPadj = Kadj * COPstd

TABLE 803.2.3(11)
PERFORMANCE REQUIREMENTS FOR
HEAT REJECTION EQUIPMENT

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Subcategory or Rating Condition	Performance Required[a,b]	Test Procedure[c]
Propeller or Axial Fan Cooling Towers	All	95°F Entering Water 85°F Leaving Water 75°F wb *Outdoor air*	≥38.2 gpm/hp	CTI ATC-105
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 R-22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering [b]	≥176,000 Btu/h·hp	ARI 460

[a] For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower divided by the fan nameplate rated motor power.

[b] For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.

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

TABLE 803.2.7
MINIMUM DUCT INSULATION

Duct Type	Duct Location	Insulation R-Value – Zone 1	Zone 2
Supply, Return	Not within conditioned space: On exterior of building, on roof, in attic, in enclosed ceiling space, in walls, in garage, in crawl spaces	R-8	R-12
		R-7	R-8
Outside Air Intake	Within conditioned space	R-7	R-7
Supply, Return, Outside air intake	Not within conditioned space: in concrete, in ground	R-5.3	R-5.3
Supply with supply air temperature <55°F or >105°F	Within conditioned space	R-3.3	R-3.3

NOTE: Requirements apply to the duct type listed, whether heated or mechanically cooled. Mechanically cooled ducts requiring insulation shall have a vapor retarder, with a perm rating not greater than 0.5 and all joints sealed.

INSULATION TYPES: Minimum densities and out of package thickness. Nominal R-values are for the insulation as installed and do not include air film resistance.

INSTALLED:

R-3.3 1.0 inch 1.5 to 3.0 lb/cu.ft. duct liner, mineral or glass fiber blanket or equivalent to provide an installed total thermal resistance of at least R-3.3.

R-5.3 2.0 inch 0.75 lb/cu.ft. mineral or glass fiber blanket, 1.5 inch 1.5 to 3.0 lb/cu.ft. duct liner, mineral or glass fiber blanket, 1.5 inch 3.0 to 7.0 lb/cu.ft. mineral or glass fiber board or equivalent to provide an installed total thermal resistance of at least R-5.3.

R-7 3.0 inch 0.75 lb/cu.ft. mineral or glass fiber blanket, 2.0 inch 1.5 to 3.0 lb/cu.ft. duct liner, mineral or glass fiber blanket, 2.0 inch 3.0 to 7.0 lb/cu.ft. mineral or glass fiber board or equivalent to provide an installed total thermal resistance of at least R-7.

TABLE 803.2.8
MINIMUM PIPE INSULATION[a]
(thickness in inches)

Fluid	Nominal Pipe Diameter	
	1.5"	> 1.5"
Steam	1%	3
Hot water	1	2
Chilled water, brine or refrigerant	1	1 1/2

For SI: 1 inch = 25.4 mm, British thermal unit per inch/h' ft2. of = W per 25 mm/K.
a. Based on insulation having a conductivity (k) not exceeding 0.27 Btu per inch/h' ft2.

803.3 Simple HVAC systems and equipment. This section applies to buildings served by unitary or packaged HVAC equipment listed in Tables 803.2.3(1) through 803.2.3(5), each serving one zone and controlled by a single thermostat in the zone served. It also applies to two-pipe heating systems serving one or more zones, where no cooling system is installed.

This section does not apply to fan systems serving multiple zones, non-unitary or non-packaged HVAC equipment and systems or hydronic or steam heating and hydronic cooling equipment and distribution systems that provide cooling or cooling and heating which are covered by Section 803.4.

803.3.1 Cooling with outdoor air. Supply air economizers shall be provided on each cooling system.

Economizers shall be capable of operating at 100-percent outdoor air, even if additional mechanical cooling is required to meet the cooling load of the building.

Systems shall provide a means to relieve excess outdoor air during economizer operation to prevent over-pressurizing the building. The relief air outlet shall be located to avoid recirculation into the building.

Where a single room or space is supplied by multiple air systems, the aggregate capacity of those systems shall be used in applying this requirement.

Exceptions:

1. Systems with air or evaporatively cooled condensers and which serve spaces with open case refrigeration or that require filtration equipment in order to meet the minimum ventilation requirements of Chapter 4 of the International Mechanical Code.
2. Systems at locations where the quality of the outdoor air is so poor as to require extensive treatment of the air.
3. Systems serving only residential spaces and hotel or motel guest rooms.
4. Cooling equipment with direct expansion coils rated at less than 54,000 Btu/hr. (15,827 W) total cooling capacity.

The total capacity of all such units without economizers shall not exceed 240,000 Btu/hr. (70,342 W) per building area served by one utility meter or service, or 10 percent of its total installed cooling capacity, whichever is greater. That portion of the equipment serving dwelling units and guest rooms is not included in determining the total capacity of units without economizers.

5. Ground-coupled heat pumps with cooling capacity of 54,000 Btu/hr. (15,827 W) or less.
6. Internal/external zone heat recovery is used.

803.3.1.1 Integration. Economizer systems shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

Exceptions:

1. Direct–expansion systems may include controls to reduce the quantity of outdoor air as required to prevent coil frosting, but not less than required by this code, at the lowest step of compressor unloading.
2. Individual direct–expansion units that have a cooling capacity of 7.5 tons (53 kW) (nominal) or less with single compressors may use economizer controls that preclude economizer operation whenever mechanical cooling is required simultaneously.

803.3.2 Hydronic system controls. Hydronic systems of at least 300,000 Btu/h (87,930 W) design output capacity supplying heated and chilled water to comfort conditioning systems shall include controls that meet the requirements of Section 803.4.3.

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

803.4.1 Zone isolation controls. A system serving multiple occupancies or floors in the same building shall be independently zoned and equipped with isolation devices capable of automatically shutting off the supply of conditioned air and outside air to and from each isolated area. Each isolated area shall be controlled independently and satisfy temperature setback (Section 803.2.5.4) and optimum start control requirements. The central fan system air volume shall be reduced through fan speed reduction.

Exception:

A cooling system less than 240,000 Btu/hr (70 kW) or a heating system with less than 300,000 Btu/hr (88 kW) total capacity does not need to meet this requirement.

803.4.2 Economizers. Supply air economizers shall be provided on each cooling system. Economizers shall be capable of operating at 100 percent outside air, even if additional mechanical cooling is required to meet the cooling load of the building.

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

803.4.3 Separate Air Distribution Systems: Zones with special process temperature requirements and/or humidity requirements shall be served by separate air distribution systems from those serving zones requiring only comfort conditions; or shall include supplementary control provisions so that the primary systems may be specifically controlled for comfort purposes only.

Exception:
Zones requiring only comfort heating or comfort cooling that are served by a system primarily used for process temperature and humidity control provided that:

1. The total supply air to those comfort zones is no more than 25% of the total system supply air, or
2. The total conditioned floor area of the zones is less than 1,000 ft^2.

803.4.4 Simultaneous Heating and Cooling: Systems which provide heating and cooling simultaneously to a zone are prohibited. Zone thermostatic and humidistatic controls shall be capable of operating in sequence the supply of heating and cooling energy to the zone. Such controls shall prevent:

a. Reheating for temperature control.
b. Recooling for temperature control.
c. Mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by economizer systems or by mechanical refrigeration.
d. Other simultaneous operation of heating and cooling systems to the same zone.
e. Reheating for humidity control.

Exception:
Zones for which the volume of air that is reheated, recooled, or mixed is no greater than the larger of the following:

a. The volume of air required to meet the ventilation requirements ASHRAE 62 for the zone.
b. 0.4 cfm/ft2 of the zone conditioned floor area, provided that the temperature of the primary system air is, by design or through reset controls, 0-12ºF below the design space heating temperature when outside air temperatures are below 60ºF for reheat systems and the cold deck of mixing systems and 0-12ºF above design space temperature when outside air temperatures are above 60ºF for recooling systems and the hot deck of mixing systems. For multiple zone systems, each zone need not comply with this exception provided the average of all zones served by the system that have both heating and cooling ability comply.
c. 300cfm. This exception is for zones whose peak flow rate totals no more than 10% of the total fan system flow rate.
d. Any higher rate that can be demonstrated, to the satisfaction of the building official, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in outdoor air intake in accordance with the multiple space requirements defined in ASHRAE Standard 62.
e. Zones where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that variable air volume systems are impractical.
f. Zones where at least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered (including condenser heat) or site-solar energy source.
g. Zones where specific humidity levels are required to satisfy process needs, such as computer rooms, museums, surgical suites, and buildings with refrigeration systems, such as supermarkets, refrigerated warehouses and ice arenas.

803.4.5 Electric Motor Efficiency: Design A & B squirrel-cage, T-frame induction permanently wired polyphase motors of 1 hp or more having synchronous speeds of 3,600, 1,800 and 1,200 rpm shall have a nominal full-load motor efficiency no less than the corresponding values for energy efficient motors provided in Table 803.4.1.

Exceptions:

1. Motors used in systems designed to use more than one speed of a multi-speed motor.
2. Motors used as a component of the equipment meeting the minimum equipment efficiency requirements of Section 803.2.3 and Tables 803.2.3(1) through 803.2.3(11) provided that the motor input is included when determining the equipment efficiency.
3. Motors that are an integral part of specialized process equipment.
4. Where the motor is integral to a listed piece of equipment for which no complying motor has been approved.

Fan motors less than 1 hp in series terminal units shall:

1. Be electronically-commutated motors, or
2. Have a minimum motor efficiency of 65% when rated in accordance with NEMA Standard MG-1 at full load rating conditions.

803.4.6 Variable air volume (VAV) fan control. Individual VAV and VVT fans with motors of 5 horsepower (3.75 kW) or greater shall be:

1. Driven by a mechanical or electrical variable speed drive; or
2. The fan motor shall have controls or devices that will result in fan motor demand of no more than 30 percent of their design wattage at 50 percent of design air flow when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.

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

803.4.7 Large volume single zone fan systems. Fan systems over 15,000 (7 m3/s) cfm that serve single zone areas including but not limited to gymnasiums, cafeterias, auditoriums or warehouses, are required to reduce airflow based on space thermostat heating and cooling demand. A two-speed motor or variable frequency drive shall reduce airflow to a maximum 60 percent of peak airflow or minimum ventilation air requirement, whichever is greater.

Exception:
Systems where the function of the supply air is for purposes other than temperature control, such as maintaining specific humidity levels or supplying an exhaust system.

803.4.8 Supply-air temperature reset controls. Multiple zone HVAC systems must include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls must be capable of resetting the supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Exceptions:
1. Systems that prevent re-heating, re-cooling, or mixing of heated and cooled supply air.
2. 75 percent of the energy for reheating is from site recovered or site solar energy sources.
3. Zones with peak supply air quantities of 300 cfm or less.

803.4.9 Motor efficiency of electric motors serving built–up HVAC systems (fans, compressors, chillers and pumps). Electric motors, which are NEMA Design A & B squirrel–cage T–frame induction permanently wired polyphase motors of 1 horsepower or more and which serve built– up HVAC systems, shall have a nominal full–load motor efficiency no less than corresponding values for energy efficient motors provided in Table 803.4.3.

Exceptions:
1. Motors used in systems designed to use more than one speed of a multi-speed motor.
2. Factory–installed motors for HVAC equipment meeting the equipment efficiency requirements of Section 803.4.8.

803.4.10 Variable speed drives. Pump motors, and fan motors serving non-VAV systems of 10 horsepower and greater which serve variable flow air or liquid systems shall be controlled by a variable speed drive. This includes custom and packaged air handlers serving variable air volume fan systems, heating and cooling hydronic pumping systems with modulating control valves, and cooling tower fans. Variable inlet vanes, throttling valves (dampers), scroll dampers or bypass circuits shall not be allowed.

Exceptions:

1. Axial vane fans with variable pitch control.
2. Dedicated equipment circulation pumps designed to meet minimum flow requirements established by manufacturer, such as boiler or chiller auxiliary circulation pumps.

803.4.11 Hydronic systems controls. The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections 803.4.3.1 through 803.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include automatic controls capable of sequencing operation of the boilers. Hydronic heating systems comprised of a single boiler and greater than 500,000 Btu/h input design capacity shall include either a multi-staged or modulating burner.

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

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

803.4.11.3 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 (11.1°C) between initiation of heat rejection and heat addition by the central devices. For Climate Zones 3 through 8 as indicated in Table 301.1, if a closed-circuit cooling tower is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower, or lower leakage positive closure dampers shall be provided. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower. If an open-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the cooling tower from the heat pump loop, 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 10 horsepower (hp) (7.5 kW) shall have a two-position valve.

Exception:

Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on real time conditions of demand and capacity, dead bands of less than 20°F (Δ11.1°C) shall be permitted.

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

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

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

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

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

Exception:
Factory-installed heat rejection devices within HVAC equipment tested and rated in accordance with Tables 803.2.3(6) through 803.2.3(11).

803.4.12 Requirements for complex mechanical systems serving multiple zones Sections 803.4.5.1 through 803.4.5.3 shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be systems which, during periods of occupancy, are designed and capable of being controlled to reduce primary air supply to each zone to one of the following before reheating, recooling or mixing takes place:

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

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

1. Zones where special pressurization relationships or cross-contamination requirements are such that VAV systems are impractical.
2. Zones or supply air systems where at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. Zones where special humidity levels are required to satisfy process needs.
4. Zones with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.
5. Zones where the volume of air to be reheated, recooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the International Mechanical Code.
6. Zones or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the zone(s) and which are capable of preventing reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

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

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

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

803.4.12.4 Air transport energy. The energy demand of each HVAC fan system shall be limited as specified in Sections 803.4.12.4.1 and 803.4.12.4.2. For the purposes of determining allowable fan motor horsepower, maximum combined fan motor horsepower is the sum of the motor brake horsepower of all fans operating at design conditions, including supply fans, return/exhaust fans and fan-powered terminal units.

Exceptions:
1. Individual HVAC fan systems with total nameplate fan system motor horsepower of 7.5 or less.
2. Individual exhaust fans with nameplate fan horsepower of 1 hp or less.

3. Induction/dilution exhaust fans used in hospitals and laboratories.
4. Fan-powered, parallel airflow terminal units where the fan does not operate in cooling mode.

803.4.12.4.1 Constant volume fan systems. For fan systems which provide a constant air volume whenever the fans are operating, the power required by the motors for the combined fan system at design conditions shall not exceed Formula CV-1 shown below. This requirement includes 2- speed motors.

Formula CV-1
BHP = Design Airflow (CFM)*4.3 4131

Fan systems with filtration systems that have a pressure drop at design air flow in excess of 1" w.c. when the filters are clean heat recovery, or direct evaporative humidifier/cooler may use Formula CV-2:

Formula CV-2
BHP = CFM * (P.D. + 4.3) 4131
where:
BHP = the maximum combined fan brake motor horsepower.
CFM = the maximum design supply air flow in cubic feet per minute.
PD = the combined pressure drop at design air flow of all filtering systems in excess of 1" w.c. when the filters are clean plus the pressure drop of heat recovery and direct evaporative humidifier/cooler in inches water gauge.

Exception:
Hospital and laboratory fan systems that incorporate flow control devices for maintaining precise pressurization control may use Section 803.4.12.4.2.

803.4.12.4.2 Variable air volume (VAV) fan systems. For fan systems which are able to vary system air volume automatically as a function of load, the power required by the motors for the combined fan system shall not exceed Formula VAV-1 shown below.

Formula VAV-1
BHP = Design Airflow (CFM) * 6.0 4131

Fan systems with filtration systems that have a pressure drop at design air flow in excess of 1" w.c. when the filters are clean heat recovery, or direct evaporative humidifier/cooler may use Formula VAV-2:

Formula VAV-2
BHP = CFM * (P.D. + 6.0)4131
where:
BHP =the maximum combined fan brake motor horsepower.
CFM = the maximum design supply air flow in cubic feet per minute.
PD = the combined pressure drop at design air flow of all filtering systems in excess of 1" w.c. when the filters are clean plus the pressure drop of heat recovery and direct evaporative humidifier/cooler in inches water gauge and additional pressure drops for hospitals and laboratories that have fully ducted return and/or exhaust systems or return and/or exhaust airflow control devices or high filtration as specified in the following table:

ADDITIONAL PD FOR HOSPITALS AND LABORATORIES

Measure Additional PD
Fully ducted return and/or exhaust air systems 0.5 in w.c.
Return and/or exhaust air flow control devices 0.5 in w.c.
Filter systems of individual filter efficiency >85% 0.5 in w.c.

803.4.12.2.3 Selecting and sizing nameplate motor horsepower: Selected fan motor shall be no larger than the first available motor size greater than the brake horsepower.

Exceptions:
1. Constant volume fans: Where the first available motor larger than the brake horsepower has a nameplate rating within 22% of the brake horsepower, the next larger nameplate motor size may be selected.
2. Fans with variable speed: Where the motor is controlled by a variable speed drive and where the first available motor larger than the brake horsepower has a nameplate rating within 50% of the brake horsepower, the next larger nameplate motor size may be selected.

803.4.13 Alternate fan power Calculation

803.4.13.1 Fan System Power Limitation: Each HVAC system at fan system design conditions shall not exceed the allowable fan system motor nameplate hp [Option 1] or fan system bhp [Option 2] as shown in Table 803.4.1.

The Motor Nameplate hp option is a simplified option that does not require complex engineering calculations.

TABLE 803.4.1 Fan Power Limitation

	Limit	Constant Volume	Variable Volume
Option 1: Fan System Motor Nameplate hp	Allowable Nameplate Motor hp	hp≤ CFM_S*0.0011	hp≤ CFM_S*0.0015
Option 2: Fan System bhp	Allowable Fan System bhp	bhp≤ CFM_S * 0.00094 + A	bhp≤ CFM_S * 0.0013 + A

where:

CFM_S = the maximum design supply fan air flow in cubic feet per minute

hp = the maximum combined motor nameplate horsepower

bhp = the maximum combined fan brake horsepower

A = Sum of [PD x CFM_D / 4131]

where:

PD = Each applicable pressure drop adjustment in inches of w.c.

CFM_D = the design air flow through each applicable device in cubic feet per minute

803.4.13.2 Series Fan Powered Terminal Systems. All series fan powered systems shall utilize option 2 from Table 803.4.1. Equivalent brake horsepower for fan powered boxes shall be calculated using the following methods and added to the brake horsepower of the central system. Published ARI watts per CFM data will be converted to brake horsepower by multiplying the rated data by 0.90 (typical central fan motor efficiency) and a correction factor (CF) for differences in operating profiles between central and terminal fans. ARI watts per cfm will be selected for the next rating point higher than the box operating point.

803.4.13.2.1 Series BHP. Series bhp = ARI watts/cfm * central fan motor efficiency * CF
where:

CF = 1.5 for constant speed fan powered boxes, 1.0 for fan powered boxes controlled to reduce flow to less than 60% of design flow during system ventilation and heating operation.

Exceptions:

1. Hospital and Laboratory Systems that utilize flow control devices on exhaust and/or return for maintaining precise pressure control may use Variable Volume Fan Power Limitation.
2. Individual exhaust fans with motor nameplate horsepower of 1 hp or less.
3. Fans exhausting air from fume hoods. (Note: If this exception is taken, no related exhaust side credits shall be taken from Table 803.4.2 and the Fume Exhaust Exception Deduction must be taken from Table 803.4.2).
4. Fan-powered, parallel airflow terminal units where the fan does not operate in cooling mode.
5. Fans used only for emergency smoke control.
6. Relief fans that run only during the economizer operation to relieve excess building pressure.

TABLE 803.4.2 Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment
Credits	
Fully ducted return and/or exhaust air systems	0.5 in w.c. (total credit per system)
Return and/or exhaust air flow control devices	0.5 in w.c (total credit per system)
Exhaust filters, scrubbers, or other exhaust treatment.	The pressure drop of device calculated at design condition air velocity.
Particulate Filtration Credit: MERV 9 thru 12	0.5 in w.c.
Particulate Filtration Cdit: MERV 13 thru 15	0.9 in w.c.
Particulate Filtration Credit: MERV 16 and greater	Pressure drop calculated at 2x clean filter pressure drop at design condition air velocity.
Carbon and Other Non-Loading Filters	Clean filter pressure drop at design condition air velocity.
Heat Recovery; Evaporative Humidifier/Cooler	The pressure drop of device calculated at design condition air velocity.
Sound Attenuation Section	The pressure drop of device calculated at design condition air velocity.
Deductions	
Fume Hood Exhaust Exception (required if 6.5.3.1.1 Exception (c) is taken)	-1.0 in w.c.

For dual duct dual fan systems, limitations apply to both heating and cooling fan system design conditions determined individually.

803.4.13.3 Motor Nameplate Horsepower: For each fan, the selected fan motor shall be no larger than the first available motor size greater than the brake horsepower. The fan brake horsepower must be indicated on the design documents to allow for compliance verification.

Exceptions:

1. For fans less than 6 bhp, where the first available motor larger than the brake horsepower has a nameplate rating within 50% of the brake horsepower, the next larger nameplate motor size may be selected.
2. For fans 6 bhp and larger, where the first available motor larger than the brake horsepower has a nameplate rating within 30% of the brake horsepower, the next larger nameplate motor size may be selected.

Table 803.4.3 Energy-efficient Electric Motors Nominal Full-Load Efficiency

SYNCHRONOUS SPEED (RPM)	OPEN MOTORS			ENCLOSED MOTORS		
	3,000	1,800	1,200	3,600	1,800	1,200
Horsepower	Efficiency	Efficiency	Efficiency	Efficiency	Efficiency	Efficiency
1	---	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2	84.0	84.0	85.5	84.0	84.0	86.5
3	84.0	86.5	86.5	85.5	87.5	87.5
5	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10	88.5	89.5	90.2	89.5	89.5	89.5
15	89.5	91.0	90.2	90.2	91.0	90.2
20	90.2	91.0	91.0	90.2	91.0	90.2
25	91.0	91.7	91.7	91.0	92.4	91.7
30	91.0	92.4	92.4	91.0	92.4	91.7
40	91.7	93.0	93.0	91.7	93.0	93.0
50	92.4	93.0	93.0	92.4	93.0	93.0
60	93.0	93.6	93.6	93.0	93.6	93.6
75	93.0	94.1	93.6	93.0	94.1	93.6
100	93.0	94.1	94.1	93.6	94.5	94.1
125	93.6	94.5	94.1	94.5	94.5	94.1
150	93.6	95.0	94.5	94.5	95.0	95.0
200	94.5	95.0	94.5	95.0	95.0	95.0

SECTION 804
SERVICE WATER HEATING

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

804.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table 804.2. The efficiency shall be verified through data furnished by the manufacturer or through certification under an approved certification program.

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

804.4 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.

804.5 Pipe insulation. For automatic-circulating hot water systems, piping shall be insulated with 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h $\times$ ft^2 $\times$ °F (1.53 W per 25 mm/m^2 $\times$ K). The first 8 feet (2438 mm) of piping in non-circulating systems shall be insulated with 1.0 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h $\times$ ft^2 $\times$ °F (1.53 W per 25 mm/m^2 $\times$ K).

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

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

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

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

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

804.8 Pools. Pools shall be provided with energy conserving measures in accordance with Sections 804.8.1 through 804.8.4.

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

804.8.2 Time switches. Time switches that can automatically turn off and on heaters and pumps according to a preset schedule shall be installed on swimming pool heaters and pumps.

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

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

804.8.4 Pool Heat recovery. Heated indoor swimming pools and Spas or Hot tubs over 200 square feet in size shall provide for energy conservation by at least one of the following methods:

1. The ventilating system shall provide a heat recovery of 70 percent at winter design conditions;
2. Heat recovered through dehumidification shall be used to heat pool, spa or hot tub room supply air.

Exception: Pools heated by renewable energy or waste heat recovery sources capable of providing at least 70 percent of the heating energy required over an operating season.

Table 804.2: Minimum Performance Of Water Heating Equipment

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED [a, b]	TEST PROCEDURE
Water heaters, Electric	,.12W	Resistance	0.97 - *0.00132V,* EF	DOE 10 CFR, Part 430
	> 12W	Resistance	*1.73V* + 155 SL, Btu/h	ANSI Z21.10.3
	,. 24 amps and 250 volts	Heat Pump	0.93 - *0.00132V,* EF	DOE 10 CFR, Part 430
Storage water heaters, Gas	,. 75,000 Btu/h	20 gal	0.67 - 0.0019V, EF	DOE 10 CFR, Part 430
	> 75,000 Btu/h and ,. 155,000 Btu/h	< 4,000 Btu/h/gal	*80%Et* (Q/800 + 110.{V) SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	*80%E* (Q/800 + 110.{V) SL, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, Gas	> 50,000 Btu/h and < 200,000 Btu/hc	4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.0019V EF	DOE 10 CFR, Part 430
	200,000 Btu/h	4,000 (Btu/h)/gal and < 10 gal	*80%Et*	ANSI Z21.10.3
	> 200,000 Btu/h	4,000 Btu/h/gal and 10 gal	*80%Et* (Q/800 + 110 .{V) SL, Btu/h	ANSI Z21.10.3
Storage water heaters, Oil	,. 105,000 Btu/h	20 gal	0.59 - 0.0019V, EF	DOE 10 CFR, Part 430
	> 105,000 Btu/h	< 4,000 Btu/h/gal	*78%E* (Q/800 + 110 .{V) SL, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, Oil	,. 210,000 Btu/h	4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019V, EF	DOE 10 CFR, Part 430
	> 210,000 Btu/h	4,000 Btu/h/gal and < 10 gal	*80%Et*	ANSI Z21.10.3
	> 210,000 Btu/h	4,000 Btu/h/gal and < 10 gal	*78%E* (0/800 + 110 .{V) SL, Btu/h	ANSI Z21.10.3
Hot water supply boilers, Gas and Oil	300,000 Btu/h and < 12,500,000 Btu/h	4,000 Btu/h/gal and < 10 gal	*80%Et*	ANSI Z21.10.3
		4,000 Btu/h/gal and 10 gal	*80%Et* (Q/800 +110.{V) SL, Btu/h	

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED [a, b]	TEST PROCEDURE
Pool heaters, Gas and Oil	All	---	*78%Et*	ASHRAE 146
Pool heaters, Heat Pump	All	---	4.0 COP	ARI 1160
Unfired storage tanks	All	---	Minimum insulation requirement: R-12.5 (h-ft^2 – °F)/Btu	(none)

For SI: °C = WF) - 32] /1.8 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.
a. Energy factor (EF) and thermal efficiency *(Et)* are minimum requirements. In the EF equation, V is the rated volume in gallons.
b. Standby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h. In the SL equation for electric water heaters, V is the rated volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons.
c. Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

SECTION 805
ELECTRICAL POWER AND LIGHTING SYSTEMS

805.1 General. This section covers lighting system controls, the connection of ballasts, the maximum lighting power for interior and exterior applications, and the minimum acceptable lighting equipment.

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

805.2.1 Interior lighting controls. Each space, enclosed by walls or ceiling-height partitions, shall be provided with lighting controls located within that space. The lighting controls, whether one or more, shall be capable of turning off all lights within the space. The controls shall be readily accessible, at the point of entry/exit, to personnel occupying or using the space.

Exceptions: The following lighting controls may be centralized in remote locations:

1. Lighting controls for spaces which must be used as a whole.
2. Controls requiring trained operators.
3. Areas designated as security or emergency areas that must be continuously lighted.
4. Lighting in stairways or corridors that are elements of the means of egress.

805.2.1.1 Control Zone Size: The maximum lighting power that may be controlled from a single switch or automatic control shall not exceed that which is provided by a 20 ampere circuit loaded to not more than 80%. A master control may be installed provided the individual switches retain their capability to function independently. Circuit breakers may not be used as the sole means of switching.

Exceptions:

1. Industrial or manufacturing process areas, as may be required for production.
2. Areas less than 5% of the building footprint for footprints over 100,000 ft2.

805.2.1 Interior lighting controls. Each space, enclosed by walls or ceiling-height partitions, shall be provided with lighting controls located within that space. The maximum lighting power that may be controlled from a single switch or automatic control shall not exceed that which is provided by a 20 ampere circuit loaded to not more than 80%.

The lighting controls, whether one or more, shall be capable of turning off all lights within the space. The controls shall be readily accessible, at the point of entry/exit, to personnel occupying or using the space. A master control may be installed provided the individual switches retain their capability to function independently. Circuit breakers may not be used as the sole means of switching.

The following lighting controls may be centralized in remote locations:

1. Lighting controls for spaces which must be used as a whole.

2. Controls requiring trained operators.
3. Lighting in stairways or corridors that are elements of the means of egress.

Exceptions:
1. Industrial or manufacturing process areas, as may be required for production.
2. Areas designated as security or emergency areas that must be continuously lighted.
3. Areas less than 5% of the building footprint for footprints over 100,000 ft2.

805.2.1.2 Daylight Zone Control: All daylit zones, both under overhead glazing and adjacent to vertical glazing, shall be provided with individual controls, or daylight- or occupant-sensing automatic controls, which control the lights independent of general area lighting.

Contiguous daylight zones adjacent to vertical glazing are allowed to be controlled by a single controlling device provided that they do not include zones facing more than two adjacent cardinal orientations (i.e. north, east, south, and west). Daylight zones under overhead glazing more than 15 feet from the perimeter shall be controlled separately from daylight zones adjacent to vertical glazing.

Exception:

Daylight spaces enclosed by walls or ceiling height partitions and containing 2 or fewer light fixtures are not required to have a separate switch for general area lighting Industrial or manufacturing process areas, as may be required for production.

805.2.2 Additional controls. Each area that is required to have a manual control shall have additional controls that meet the requirements of Sections 805.2.2.1 and 805.2.2.2.
805.2.2.1 Light reduction controls. Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or other approved method:

1. Controlling all lamps or luminaires;
2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps;
3. Switching the middle lamp luminaires independently of the outer lamps; or
4. Switching each luminaire or each lamp.

Exceptions:
1. Areas that have only one luminaire.
2. Areas that are controlled by an occupant-sensing device.
3. Corridors, storerooms, restrooms or public lobbies.
4. Guestrooms (see Section 805.2.3).
5. Spaces that use less than 0.6 watts per square foot (6.5 W/m^2).

805.2.2.2 Automatic lighting shutoff. Buildings larger than 5,000 square feet (465 m^2) and office occupancies over 2000 square feet of contiguous area shall be equipped with an automatic control device to shut off lighting in those areas. Automatic controls shall be an occupancy sensor, time switch or other device capable of automatically shutting off lighting that complies with Section 805.2.2.2.1.

Offices less than 300 square feet (27.9 m_2), meeting and conference rooms, and school classrooms shall be equipped with occupancy sensors that comply with Section 805.2.2.2.1.

Exceptions:
1. Emergency and pathway lights as required by code.
2. Where the system is serving an area that must be continuously lit.
3. Display and accent lighting, including plug–in, track and display case lighting, shall be separately controlled.
4. Switching for industrial or manufacturing process facilities as may be required for production.
5. Hospitals and laboratory spaces.
6. Areas in which medical or dental tasks are performed.
7. Mechanical and electrical equipment rooms.

805.2.2.2.1 Occupancy sensors. Occupancy sensors shall be capable of automatically turning off all the lights in an area, no more than 30 minutes after the area has been vacated. Lighting fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning on and off lights when the space is occupied.

805.2.2.2.2 Automatic time switches. Automatic time switches shall have a minimum 7-day clock and be capable of being set for 7 different day types per week. Automatic time switches shall also have program back-up capabilities, which prevent the loss of program and time settings for at least 10 hours, if power is interrupted.

Automatic time switches shall incorporate an over-ride switching device that:
1. Is readily accessible,
2. Is located so that a person using the device can see the effects of the control,
3. Is manually operated,

4. Allows the lighting to remain on for no more than 2 hours when an over-ride is initiated, and
5. Controls an area not exceeding 2,000 ft^2 (186 m^2).

Exception: Guestrooms (see Section 805.2.3).
a. Lighting in spaces where patient care is directly provided.
b. Spaces where an automatic shutoff would endanger occupant safety or security.

In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, where captive-key override is utilized, override time may exceed 2 hours. In these spaces the area controlled may not exceed 20,000 square feet (1860 m2).

805.2.2.2.2.1 Holiday scheduling. If an automatic time switch control device is installed in accordance with Section 805.2.2.2, Item 1, it shall incorporate an automatic holiday scheduling feature that turns off all loads for at least 24 hours, and then resumes the normally scheduled operation.

> **Exception:**
> Retail stores and associated malls, restaurants, grocery stores, churches and theaters do not need to meet this holiday scheduling requirement.

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

805.2.4 Exterior Lighting Controls. Lighting for all exterior applications, including signs, shall be capable of being automatically switched off during daylight hours and non-use nighttime hours by either a combination of timer and photocell, or a timer with astronomic control. Astronomical time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least 10 hours.

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

805.2.5 Commissioning Requirements. For lighting controls which include daylight or occupant sensing automatic controls, automatic shut-off controls, occupancy sensors, or automatic time switches, the lighting controls shall be tested to ensure that control devices, components, equipment and systems are calibrated, adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to ensure they operate in accordance with approved plans and specifications. A complete report of test procedures and results shall be prepared and filed with the owner. Drawing notes shall require commissioning in accordance with this paragraph.

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

1. Fluorescent luminaires equipped with one, three or odd-numbered lamp configurations, that are recess-mounted within 10 feet (3048 mm) center-to-center of each other.
2. Fluorescent luminaires equipped with one, three or any other odd-numbered lamp configuration, that are pendant- or surface-mounted within 1 foot (305 mm) edge-to-edge of each other.

Exceptions:
1. Where electronic high-frequency ballasts are used.
2. Luminaires on emergency circuits.
3. Luminaires with no available pair in the same area.

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

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

805.5.1 Total connected interior lighting power. The total connected interior lighting power (Watts) shall be the sum of the watts of all interior lighting equipment as determined in accordance with Sections 805.5.1.1 through 805.5.1.4.

Exceptions: The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
1. Specialized medical, dental and research lighting.
2. Display lighting for exhibits in galleries, museums and monuments.
3. Emergency lighting automatically off during normal building operation.

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

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

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

805.5.1.4 Line-voltage lighting track and plug-in busway. The wattage shall be the greater of the wattage of the luminaires determined in accordance with Sections 805.5.1.1 through 805.5.1.3 or 50 W/linear foot (98W/lin m).

805.5.2 Interior Lighting Power. The total interior lighting power (Watts) is the sum of all interior lighting powers for all areas in the building covered in this permit. The interior lighting power is the floor area for each building area type listed in Table 805.5.2 times the value from Table 805.5.2 for that area. For the purposes of this method, an "area" shall be defined as all contiguous spaces that accommodate or are associated with a single area type as listed in Table 805.5.2. When this method is used to calculate the total interior lighting power for an entire building, each building area type shall be treated as a separate area.

805.6 Exterior lighting. When the power for exterior lighting is supplied through the energy service to the building, all exterior lighting, other than low-voltage landscape lighting, shall comply with Sections 805.6.1 and 806.6.2.

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

805.6.1 Exterior Building Grounds Lighting. All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lumens per watt unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under Section 805.6.2.

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

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

a. specialized signal, directional, and marker lighting associated with transportation;
b. advertising signage or directional signage;
c. integral to equipment or instrumentation and is installed by its manufacturer;
d. theatrical purposes, including performance, stage, film production and video production;
e. athletic playing areas;
f. temporary lighting;
g. industrial production, material handling, transportation sites, and associated storage areas;
h. theme elements in theme/amusement parks; and
I. used to highlight features of public monuments and registered historic landmark structures or buildings.

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

TABLE 805.5.2
INTERIOR LIGHTING POWER ALLOWANCES

Building Area Type [a]	(W/ft2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Cafeteria/Fast Food	1.4
Dining: All Other	1.0
Dormitory	1.0
Exercise Center	1.0
Gymnasium/Auditorium	1.0
Healthcare-Clinic	1.0
Hospital/Nursing Home	1.2
Hotel, Common	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theater	1.0
Multi-Family, Common Area	0.7
Museum	1.1
Office	1.0
Penitentiary	1.0
Performing Arts Theater	1.0
Police Station	1.0
Fire Station	0.8
Post Office	1.1
Religious Building	1.0
Retail [b]	1.5
School/University	1.1
Sports Arena	1.0
Transportation Terminals	1.0
Warehouse	0.8
Workshop	1.4

TABLE 805.6.2
Lighting Power Densities for Building Exteriors

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**	
	Uncovered Parking Lots and drives	**0.15**W/ft2
	Building Grounds	
	Walkways less than 10 feet wide	1.0W/linear foot
	Walkways 10 feet wide or greater	0.2W/sf
	Plaza areas	0.2W/ft2
	Special Feature Areas	1.0 W/ft2
	Stairways	1.0 W/ft2

	Building Entrances and Exits	
	Main entries	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width
	Canopies and Overhangs	
	Sales Canopies (free standing, attached and overhangs) Non-sales Canopies	1.00W/ft2 0.2W/ft2
	Outdoor Sales	
	Open areas (including vehicle sales lots)	0.5W/ft2
Non-Tradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and can-not be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "tradable Surfaces" section of this table.)	**Building Facades**	0.15 W/ft2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	1.25 W/ft2of 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/ft2of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Covered Parking, Garages	0.2 W/ft2

[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, and fixtures swivel in 2 dimensions, the smaller of the actual wattage of the lighting equipment installed specifically for merchandise, or 1.5 W/ft2 times the area of the specific display but not to exceed 50% of the floor area, shall be added to the interior lighting power determined in accordance with this line item.

SECTION 806
NON-RESIDENTIAL BUILDING DESIGN BY SYSTEMS ANALYSIS

806.1 Scope

806.1.1 General: This Section establishes design criteria in terms of total energy consumption of a building, including all of its systems. General principles and requirements are outlined in Section 806.2. Specific modeling assumptions are listed in Section 806.3.

806.1.2 Application: Due to the various assumptions that are necessary, the results of the analysis shall not be construed as a guarantee of the actual energy performance of the project.

806.2 General Principles and Requirements

806.2.1 Energy Analysis: Compliance with this Standard will require an analysis of the annual energy usage, hereinafter called an annual energy analysis.

A building designed in accordance with this Standard will be deemed as complying, if:

1. The calculated annual energy consumption is not greater than that of a corresponding "standard design," as defined below and in Section 806.3; and,
2. Whose enclosure elements and energy-consuming systems comply with Sections 801 through 805. Buildings shall only vary from those requirements in Sections 802.2, 802.3, 803.2.2, 803.2.3, 803.2.5, 803.2.6, 803.4, 805.5 and 805.6 where those variations have been accurately and completely modeled. Where variations are not specifically analyzed, the building shall comply with these requirements.

For a proposed building design to be considered similar to a "standard design," it shall utilize the same energy source(s) for the same functions and have equal floor area and the same ratio of envelope area to floor area, environmental requirements, occupancy, climate data and usage operational schedule. Inputs to the energy analysis relating to occupancy and usage shall correspond to the expected occupancy and usage of the building.

Except as noted below, the systems identified, and, to the extent possible, the assumptions made in assigning energy inputs to each system, shall be the same for the standard design and the proposed design. When electrically driven heat pumps, other than multiple units connected to a common water loop, are employed to provide all or part of the heat for the proposed design, the standard design shall also, for the purposes of the analysis, assume that an electrically driven heat pump, in conformance with Section 803 and having capacity at least as great as those used in the proposed design are employed.

806.2.2 Design: The standard design and the proposed design shall be designed on a common basis as specified herein:

a. The comparison shall be expressed as kBtu input per square foot of conditioned floor area per year at the building site. For buildings which use electricity as the only fuel source, comparisons may be expressed in kWh. When converting electricity in kWh to kBtu a multiplier of 3.413 kWh/kBtu shall be used.

b. If the proposed design results in an increase in consumption of one energy source and a decrease in another energy source, even though similar sources are used for similar purposes, the difference in each energy source shall be converted to equivalent energy units for purposes of comparing the total energy used.

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

a. The building heating/cooling load calculation procedure used for annual energy consumption analysis shall be detailed to permit the evaluation of effect of factors specified in Section 806.2.4. The calculation procedure used to simulate the operation of the building and its service systems through a full-year operating period shall be detailed to permit the evaluation of the effect of system design, climatic factors, operational characteristics and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data shall be used when available in the simulation of systems and equipment. The calculation procedure shall be based upon 8,760 hours of operation of the building and its service systems and shall utilize simulation programs listed in section 806.4.

806.2.4 Calculation Procedure: The calculation procedure shall cover the following items:

a. Design requirements: Design heating conditions and design cooling conditions as defined in Chapter 2.

b. Climatic data: Coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation.

c. Building data: Orientation, size, shape, mass, air and heat transfer characteristics.

d. Operational characteristics: Temperature, humidity, ventilation, illumination and control mode for occupied and unoccupied hours.

e. Mechanical equipment: Design capacity and part load profile.

f. Building loads: Internal heat generation, lighting, equipment and number of people during occupied and unoccupied periods.

806.2.5 Documentation: All analyses submitted shall be accompanied by an energy analysis comparison report. The report shall provide technical detail on the standard and proposed building and system designs, and on the data used in and resulting from the comparative analysis in order to verify that both the analysis and the designs meet the criteria of Section 806.1.

The calculation procedure for the standard design and the proposed design shall separately identify the calculated annual energy consumption for each different occupancy type, if possible, for each of the following end uses:

a. Interior lighting;
b. Parking lighting;
c. Exterior lighting;
d. Space heating;
e. Space cooling;
f. Interior ventilation/fans;
g. Parking ventilation/fans;
h. Exhaust fans;
i. Service water hearing;
j. Elevators; and
k. Appliances.

Energy consumption of the following items shall be included but is not required to be separated out by each individual item:

a. Office equipment;
b. Refrigeration other than comfort cooling;
c. Cooking; and
d. Any other energy-consuming equipment.

The specifications of the proposed building project used in the analysis shall be as similar as is reasonably practical to those in the plans submitted for a building permit.

806.3 Specific Modeling Assumptions:

806.3.1 General: The specific modeling assumptions consist of methods and assumptions for calculating the standard energy consumption for the standard building and the proposed energy consumption of the proposed design. In order to maintain consistency between the standard and the proposed design energy consumptions, the input assumptions in this section shall be used.

"Prescribed" assumptions shall be used without variation. "Default" assumptions shall be used unless the designer can demonstrate that a different assumption better characterizes the building's use over its expected life. Any modification of a default assumption shall be used in modeling both the standard building and the proposed design unless the designer demonstrates a clear cause to do otherwise.

806.3.2 Orientation, Shape and Internal Loads: The standard building shall consist of the same number of stories and gross floor area for each story as the proposed design. Each floor shall be oriented exactly as the proposed design. The geometric form shall be the same as the proposed design. Internal loads shall be modeled as follows. These guidelines are not intended as requirements or recommendations for systems to be used in the proposed building or for the calculation of the proposed energy consumption.

806.3.2.1 Occupancy: Occupancy schedules shall be default assumptions. The same assumptions shall be made in computing proposed energy consumption as were used in calculating the standard energy consumption. Occupancy levels vary by building type and time of day. Table 806.3.1 establishes the density presented as ft^2/person of conditioned floor area that will be used by each building type. Tables 806.3.2 establish the percentage of the people that are in the building by hours of the day for each building type.

806.3.2.2 Lighting: The interior and exterior lighting power allowance for calculating the standard energy consumption shall be determined from Sections 805.5 and 805.6. The lighting power used to calculate the proposed energy consumption shall be the actual lighting power of the proposed lighting design. Exempt lighting in the standard design shall be equal to the exempt lighting in the proposed design.

Lighting levels in buildings vary based on the type of uses within buildings, by area and by time of day. Table 806.3.2 contains the lighting energy profiles which establish the percentage of the lighting load that is switched ON in each prototype or reference building by hour of the day. These profiles are default assumptions and can be changed if required when calculating the standard energy consumption to provide, for example, a 12-hour rather than an 8-hour work day or to reflect the use of automatic lighting controls. The lighting schedules used in the standard and proposed designs shall be identical and shall reflect the type of controls to be installed in the proposed design. The controls in the proposed design shall comply with the requirements in Section 805.2 and no credit shall be given for the use of any additional controls, automatic or otherwise.

806.3.2.3 Receptacle: Receptacle loads and profiles are default assumptions. The same assumptions shall be made in calculating proposed energy consumption as were used in calculating the standard energy consumption. Receptacle loads include all general service loads that are typical in a building. These loads should include additional process electrical usage but exclude HVAC primary or auxiliary electrical usage. Table 806.3.1 establishes the density in W/ft^2 to be used. The receptacle energy profiles shall be the same as the lighting energy profiles in Tables 806.3.2. This profile establishes the percentage of the receptacle load that is switched ON by hour of the day and by building type.

806.3.3 Envelope

806.3.3.1 Insulation and Glazing: Glazing area and U-factor of the standard building envelope shall be determined by using Table 802.2 and Section 802.2.2. The insulation characteristics and glazing area are prescribed assumptions for the standard building for calculating the standard energy consumption. In the calculation of the proposed energy consumption of the

proposed design, the envelope characteristics of the proposed design shall be used. The standard design shall use the maximum glazing areas listed in Table 802.2 for the appropriate use.

The distribution of vertical glazing in the gross wall area of the standard design shall be equal to the distribution of vertical glazing in the proposed design or shall constitute an equal percentage of gross wall area on all sides of the standard building. The distribution of overhead glazing in the gross roof/ceiling area of the standard design shall be equal to the distribution of overhead glazing in the proposed design. The distribution of doors in the gross opaque wall area of the standard design shall be identical to the distribution of doors in the proposed design.

806.3.3.2 Infiltration: For standard and proposed buildings, infiltration assumptions shall be equal.

806.3.3.3 Envelope and Ground Absorptivities: For the standard building, absorptivity assumptions shall be default assumptions for computing the standard energy consumption and default assumptions for computing the proposed energy consumption. The solar absorptivity of opaque elements of the building envelope shall be assumed to be 70%. The solar absorptivity of ground surfaces shall be assumed to be 80% (20% reflectivity).

806.3.3.4 Window Treatment: No draperies or blinds shall be modeled for the standard or proposed building.

806.3.3.5 Shading: For the standard building and the proposed design, shading by permanent structures and terrain shall be taken into account for computing energy consumption whether or not these features are located on the building site. A permanent fixture is one that is likely to remain for the life of the proposed design. Credit may be taken for external shading devices that are part of the proposed design.

806.3.4 HVAC Systems and Equipment: For the standard building, the HVAC system used shall be the system type used in the proposed design. If the proposed HVAC system type does not comply with Section 803, the standard design system shall comply in all respects with that section.

> **EXCEPTION:** A prototype HVAC system may be used as a standard design if the proposed design system cannot be modified to comply with Section 803. Use of prototype HVAC systems shall only be permitted for the building types listed below. For mixed-use buildings, the floor space of each building type is allocated within the floor space of the standard building. The specifications and requirements for the HVAC systems of prototype buildings shall be those in Table 806.3.3.
>
> 1. assembly
> 2. health/institutional
> 3. hotel/motel
> 4. light manufacturing
> 5. office (business)
> 6. restaurant
> 7. retail (mercantile)
> 8. school (educational)
> 9. warehouse (storage)

806.3.4.1 HVAC Zones: HVAC zones for calculating the standard energy consumption and proposed energy consumption shall consist of at least four perimeter zones and one interior zone per floor, with at least one perimeter zone facing each orientation. The perimeter zones shall be 15 feet in width or one-third the narrow dimension of the building when this dimension is between 30 and 45 feet inclusive, or half the narrow dimension of the building when this dimension is less than 30 feet.

> **EXCEPTIONS:** 1. Building types such as assembly or warehouse may be modeled as a single zone if there is only one space.
>
> 2. Thermally similar zones, such as those facing one orientation on different floors, may be grouped together for the standard and/or proposed building simulation.

806.3.4.2 Process Equipment Sizing: Process sensible and latent loads shall be equal in calculating both the standard energy consumption and the proposed energy consumption. The designer shall document the installation of process equipment and the size of process loads.

806.3.4.3 HVAC Equipment Sizing: The equipment shall be sized to include the capacity to meet the process loads. For calculating the proposed energy consumption, actual air flow rates and installed equipment size shall be used in the simulation. Equipment sizing in the simulation of the proposed design shall correspond to the equipment intended to be selected for the design and the designer shall not use equipment sized automatically by the simulation tool.

Equipment sizing for the standard design shall be based on the same as the proposed design or lesser sizing ratio of installed system capacity to the design load for heating and for cooling.

Chilled water systems for the standard building shall be modeled using a reciprocating chiller for systems with total cooling capacities less than 175 tons, and centrifugal chillers for systems with cooling capacities of 175 tons or greater. For systems with cooling capacities of 600 tons or more, the standard energy consumption shall be calculated using two centrifugal chillers, lead/lag controlled. Chilled water shall be assumed to be controlled at a constant 44°F temperature rise, from 44°F to 56°F, operating at 65% combined impeller and motor efficiency. Condenser water pumps shall be sized using a 10°F temperature rise, operating at 60% combined impeller and motor efficiency. The cooling tower shall be an open circuit, centrifugal blower type sized for the larger of 85°F leaving water temperature or 10°F approach to design wet bulb temperature. The tower shall be controlled to provide a 65°F leaving water temperature whenever weather conditions permit, floating up to design leaving water temperature at design conditions.

806.3.4.4 Fans: The power of the combined fan system per air volume at design conditions (w/cfm) of the proposed design shall be equal to that of the standard design.

Variable air volume fan systems in the standard building shall be variable speed.

806.3.5 Service Water Heating: The service water heating loads for prototype buildings are defined in terms of Btu/person-hour in Table 806.3.1. The values in the table refer to energy content of the heated water. The service water heating loads from Table 806.3.1 are default for all buildings. The same service-water-heating load assumptions shall be made in calculating proposed energy consumption as were used in calculating the standard energy consumption. The service water heating system for the standard building shall be modeled based on a design in accordance with ASHRAE HVAC Applications Handbook and meeting all the requirements of Section 804.

806.3.6 Controls

806.3.6.1: All occupied conditioned spaces in standard and proposed design buildings in all climates shall be simulated as being both heated and cooled.

EXCEPTIONS: 1. If a building or portion of a building is to be provided with only heating or cooling, both the standard building and the proposed design shall be simulated using the same assumptions.

2. If warehouses are not intended to be mechanically cooled, both the standard and proposed energy consumption shall be modeled assuming no mechanical cooling.

806.3.6.2: Space temperature controls for the standard building shall be set at 70°F for space heating and 75°F for space cooling, with a dead band in accordance with Section 803.2.5. The system shall be OFF during off-hours according to the appropriate schedule in Tables 806.3.2, except that the heating system shall cycle ON if any space should drop below the night setback setting of 55°F. There shall be no similar set point during the cooling season. Lesser dead band ranges may be used in calculating the proposed energy consumption.

EXCEPTIONS: 1. Setback shall not be modeled in determining either the standard or proposed energy consumption if setback is not realistic for the proposed design, such as a facility being operated 24 hours/day. For instance, health facilities need not have night setback during the heating season.

2. If dead band controls are not to be installed, the proposed energy consumption shall be calculated with both heating and cooling thermostat set points set to the same value between 70°F and 75°F inclusive, assumed to be constant for the year.

806.3.6.3: When providing for outdoor air ventilation to calculate the standard energy consumption, controls shall be assumed to close the outside air intake to reduce the flow of outside air to 0.0 CFM during “setback” and “unoccupied” periods. Ventilation using inside air may still be required to maintain scheduled setback temperature. Outside air ventilation, during occupied periods, shall be as required by ASHRAE Standard 62-2004.

806.3.6.4: If humidification is to be used in the proposed design, the same level of humidification and system type shall be used in the standard building.

806.3.6.5: There shall be no credit in the proposed design for control of parking garage ventilation.

TABLE 806.3.1

Acceptable Occupancy Densities, Receptacle Power Densities and Service Hot Water Consumption[1]

Building Type	Occupancy Density[2] Sq.Ft./Person ($Btu/h \cdot ft^2$)	Receptacle Power Density[3] Watts/Sq.Ft. ($Btu/h \cdot ft^2$)	Service Hot Water Quantities[4] Btu/h · Person
Assembly	50 (4.60)	0.25 (0.85)	215
Health/Institutional	200 (1.15)	1.00 (3.41)	135
Hotel/Motel	250 (0.92)	0.25 (0.85)	1,110
Light Manufacturing	750 (0.31)	0.20 (0.68)	225
Office	275 (0.84)	0.75 (2.56)	175
Parking Garage	NA	NA	NA
Restaurant	100 (2.30)	0.10 (0.34)	390
Retail	300 (0.77)	0.25 (0.85)	135
School	75 (3.07)	0.50 (1.71)	215
Warehouse	15,000 (0.02)	0.10 (0.34)	225

1. The occupancy densities, receptacle power densities, and service hot water consumption values are from ASHRAE Standard 90.1and addenda.
2. Values are in square feet of conditioned floor area per person. Heat generation in Btu per person per hour is 230 sensible and 190 latent. Figures in parenthesis are equivalent Btu per hour per square foot.
3. Values are in Watts per square foot of conditioned floor area. Figures in parenthesis are equivalent Btu per hour per square foot. These values are the minimum acceptable. If other process loads are not input (such as for computers, cooking, refrigeration, etc.), it is recommended that receptacle power densities be increased until total process energy consumption is equivalent to 25% of the total.
4. Values are in Btu per person per hour.

TABLE 806.3.2A
Assembly Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
2 (1-2 am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
3 (2-3 am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
4 (3-4 am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
5 (4-5 am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
6 (5-6 am)	0	0	0	5	5	5	On	Off	Off	0	0	0	0	0	0
7 (6-7 am)	0	0	0	40	5	5	On	On	On	0	0	0	0	0	0
8 (7-8 am)	0	0	0	40	30	30	On	On	On	0	0	0	0	0	0
9 (8-9 am)	20	20	10	40	30	30	On	On	On	0	0	0	0	0	0
10 (9-10 am)	20	20	10	75	50	30	On	On	On	5	5	5	0	0	0
11 (10-11 am)	20	20	10	75	50	30	On	On	On	5	5	5	0	0	0
12 (11-12 pm)	80	60	10	75	50	30	On	On	On	35	20	10	0	0	0
13 (12-1 pm)	80	60	10	75	50	65	On	On	On	5	0	0	0	0	0
14 (1-2 pm)	80	60	70	75	50	65	On	On	On	5	0	0	0	0	0
15 (2-3 pm)	80	60	70	75	50	65	On	On	On	5	0	0	0	0	0
16 (3-4 pm)	80	60	70	75	50	65	On	On	On	5	0	0	0	0	0
17 (4-5 pm)	80	60	70	75	50	65	On	On	On	5	0	0	0	0	0
18 (5-6 pm)	80	60	70	75	50	65	On	On	On	0	0	0	0	0	0
19 (6-7 pm)	20	60	70	75	50	65	On	On	On	0	0	0	0	0	0
20 (7-8 pm)	20	60	70	75	50	65	On	On	On	0	65	65	0	0	0
21 (8-9 pm)	20	60	70	75	50	65	On	On	On	0	30	30	0	0	0
22 (9-10 pm)	20	80	70	75	50	65	On	On	On	0	0	0	0	0	0
23 (10-11 pm)	10	10	20	25	50	5	On	On	On	0	0	0	0	0	0
24 (11-12 am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
Total/Day	710	750	700	1155	800	845	1800	1700	1700	70	125	115	0	0	0
Total/Week		50.50 hours			74.20 hours			124 hours			5.9 hours				0 hours
Total/Year		2633 hours			3869 hours			6465 hours			308 hours				0 hours

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2B
Health Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
2 (1-2 am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
3 (2-3 am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
4 (3-4 am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
5 (4-5 am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
6 (5-6 am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
7 (6-7 am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
8 (7-8 am)	10	10	0	50	20	5	On	On	On	17	1	1	2	2	0
9 (8-9 am)	50	30	5	90	40	10	On	On	On	58	20	1	75	46	2
10 (9-10 am)	80	40	5	90	40	10	On	On	On	66	28	1	100	70	2
11 (10-11 am)	80	40	5	90	40	10	On	On	On	78	30	1	100	70	2
12 (11-12 pm)	80	40	5	90	40	10	On	On	On	82	30	1	100	70	2
13 (12-1 pm)	80	40	5	90	40	10	On	On	On	71	24	1	75	51	2
14 (1-2 pm)	80	40	5	90	40	10	On	On	On	82	24	1	100	51	2
15 (2-3 pm)	80	40	5	90	40	10	On	On	On	78	23	1	100	51	2
16 (3-4 pm)	80	40	5	90	40	10	On	On	On	74	23	1	100	51	2
17 (4-5 pm)	80	40	0	30	40	5	On	On	On	63	23	1	100	51	0
18 (5-6 pm)	50	10	0	30	40	5	On	On	On	41	10	1	100	25	0
19 (6-7 pm)	30	10	0	30	10	5	On	On	On	18	1	1	52	2	0
20 (7-8 pm)	30	0	0	30	10	5	On	On	On	18	1	1	52	0	0
21 (8-9 pm)	20	0	0	30	10	5	On	On	On	18	1	1	52	0	0
22 (9-10 pm)	20	0	0	30	10	5	On	On	On	10	1	1	28	0	0
23 (10-11 pm)	0	0	0	30	10	5	On	On	On	1	1	1	0	0	0
24 (11-12 am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
Total/Day	850	380	40	1060	550	160	2400	2400	2400	783	249	24	1136	540	16
Total/Week		46.70 hours			60.10 hours			168 hours			41.88 hours			62.36 hours	
Total/Year		2435 hours			3134 hours			8760 hours			2148 hours			3251 hours	

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2C
Hotel/Motel Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	90	90	70	20	20	30	On	On	On	20	20	25	40	44	55
2 (1-2 am)	90	90	70	15	20	30	On	On	On	15	15	20	33	35	55
3 (2-3 am)	90	90	70	10	10	20	On	On	On	15	15	20	33	35	43
4 (3-4 am)	90	90	70	10	10	20	On	On	On	15	15	20	33	35	43
5 (4-5 am)	90	90	70	10	10	20	On	On	On	20	20	20	33	35	43
6 (5-6 am)	90	90	70	20	10	20	On	On	On	25	25	30	33	35	43
7 (6-7 am)	70	70	70	40	30	30	On	On	On	50	40	50	42	40	52
8 (7-8 am)	40	50	70	50	30	40	On	On	On	60	50	50	42	32	52
9 (8-9 am)	40	50	50	40	40	40	On	On	On	55	50	50	52	45	65
10 (9-10 am)	20	30	50	40	40	30	On	On	On	45	50	55	52	45	65
11 (10-11 am)	20	30	50	25	30	30	On	On	On	40	45	50	40	42	53
12 (11-12 pm)	20	30	30	25	25	30	On	On	On	45	50	50	51	60	60
13 (12-1 pm)	20	30	30	25	25	30	On	On	On	40	50	40	51	65	53
14 (1-2 pm)	20	30	20	25	25	20	On	On	On	35	45	40	51	65	51
15 (2-3 pm)	20	30	20	25	25	20	On	On	On	30	40	30	51	65	50
16 (3-4 pm)	30	30	20	25	25	20	On	On	On	30	40	30	51	65	44
17 (4-5 pm)	50	30	30	25	25	20	On	On	On	30	35	30	63	65	64
18 (5-6 pm)	50	50	40	25	25	20	On	On	On	40	40	40	80	75	62
19 (6-7 pm)	50	60	40	60	60	50	On	On	On	55	55	50	86	80	65
20 (7-8 pm)	70	60	60	80	70	70	On	On	On	60	55	50	70	80	63
21 (8-9 pm)	70	60	60	90	70	80	On	On	On	50	50	40	70	75	63
22 (9-10 pm)	80	70	80	80	70	60	On	On	On	55	55	50	70	75	63
23 (10-11 pm)	90	70	80	60	60	50	On	On	On	45	40	40	45	55	40
24 (11-12 am)	90	70	80	30	30	30	On	On	On	25	30	20	45	55	40
Total/Day	1390	1390	1300	855	785	810	2400	2400	2400	915	930	900	1217	1303	1287
Total/Week		96.40 hours			58.70 hours			168.0 hours			64.05 hours			86.75 hours	
Total/Year		5026 hours			3061 hours			8760 hours			3340 hours			4523 hours	

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2D
Light Manufacturing Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
2 (1-2 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
3 (2-3 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
4 (3-4 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
5 (4-5 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
6 (5-6 am)	0	0	0	10	5	5	Off	Off	Off	8	8	7	0	0	0
7 (6-7 am)	10	10	5	10	10	5	On	On	Off	7	7	4	0	0	0
8 (7-8 am)	20	10	5	30	10	5	On	On	Off	19	11	4	35	16	0
9 (8-9 am)	95	30	5	90	30	5	On	On	Off	35	15	4	69	14	0
10 (9-10 am)	95	30	5	90	30	5	On	On	Off	38	21	4	43	21	0
11 (10-11 am)	95	30	5	90	30	5	On	On	Off	39	19	4	37	18	0
12 (11-12 pm)	95	30	5	90	30	5	On	On	Off	47	23	6	43	25	0
13 (12-1 pm)	50	10	5	80	15	5	On	On	Off	57	20	6	58	21	0
14 (1-2 pm)	95	10	5	90	15	5	On	On	Off	54	19	9	48	13	0
15 (2-3 pm)	95	10	5	90	15	5	On	On	Off	34	15	6	37	8	0
16 (3-4 pm)	95	10	5	90	15	5	On	On	Off	33	12	4	37	4	0
17 (4-5 pm)	95	10	5	90	15	5	On	On	Off	44	14	4	46	5	0
18 (5-6 pm)	30	5	5	50	5	5	On	On	Off	26	7	4	62	6	0
19 (6-7 pm)	10	5	0	30	5	5	On	Off	Off	21	7	4	20	0	0
20 (7-8 pm)	10	0	0	30	5	5	On	Off	Off	15	7	4	12	0	0
21 (8-9 pm)	10	0	0	20	5	5	On	Off	Off	17	7	4	4	0	0
22 (9-10 pm)	10	0	0	20	5	5	On	Off	Off	8	9	7	4	0	0
23 (10-11 pm)	5	0	0	10	5	5	Off	Off	Off	5	5	4	0	0	0
24 (11-12 am)	5	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
Total/Day	920	200	60	1040	280	120	1600	1200	0	537	256	113	555	151	0
Total/Week		48.60 hours			56.00 hours			92.00 hours			30.54 hours			29.26 hours	
Total/Year		2534 hours			2920 hours			4797 hours			1592 hours			1526 hours	

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2E
Office Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
2 (1-2 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
3 (2-3 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
4 (3-4 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
5 (4-5 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
6 (5-6 am)	0	0	0	10	5	5	Off	Off	Off	8	8	7	0	0	0
7 (6-7 am)	10	10	5	10	10	5	On	On	Off	7	7	4	0	0	0
8 (7-8 am)	20	10	5	30	10	5	On	On	Off	19	11	4	35	16	0
9 (8-9 am)	95	30	5	90	30	5	On	On	Off	35	15	4	69	14	0
10 (9-10 am)	95	30	5	90	30	5	On	On	Off	38	21	4	43	21	0
11 (10-11 am)	95	30	5	90	30	5	On	On	Off	39	19	4	37	18	0
12 (11-12 pm)	95	30	5	90	30	5	On	On	Off	47	23	6	43	25	0
13 (12-1 pm)	50	10	5	80	15	5	On	On	Off	57	20	6	58	21	0
14 (1-2 pm)	95	10	5	90	15	5	On	On	Off	54	19	9	48	13	0
15 (2-3 pm)	95	10	5	90	15	5	On	On	Off	34	15	6	37	8	0
16 (3-4 pm)	95	10	5	90	15	5	On	On	Off	33	12	4	37	4	0
17 (4-5 pm)	95	10	5	90	15	5	On	On	Off	44	14	4	46	5	0
18 (5-6 pm)	30	5	5	50	5	5	On	On	Off	26	7	4	62	6	0
19 (6-7 pm)	10	5	0	30	5	5	On	Off	Off	21	7	4	20	0	0
20 (7-8 pm)	10	0	0	30	5	5	On	Off	Off	15	7	4	12	0	0
21 (8-9 pm)	10	0	0	20	5	5	On	Off	Off	17	7	4	4	0	0
22 (9-10 pm)	10	0	0	20	5	5	On	Off	Off	8	9	7	4	0	0
23 (10-11 pm)	5	0	0	10	5	5	Off	Off	Off	5	5	4	0	0	0
24 (11-12 am)	5	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
Total/Day	920	200	60	1040	280	120	1600	1200	0	537	256	113	555	151	0
Total/Week		48.60 hours			56.00 hours			92.00 hours			30.54 hours			29.26 hours	
Total/Year		2534 hours			2920 hours			4797 hours			1592 hours			1526 hours	

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2F
Parking Garage Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)				100	100	100									
2 (1-2 am)				100	100	100									
3 (2-3 am)				100	100	100									
4 (3-4 am)				100	100	100									
5 (4-5 am)				100	100	100									
6 (5-6 am)				**100**	**100**	**100**									
7 (6-7 am)				100	100	100									
8 (7-8 am)				100	100	100									
9 (8-9 am)				100	100	100									
10 (9-10 am)				100	100	100									
11 (10-11 am)				100	100	100									
12 (11-12 pm)		NA		100	100	100		Based on likely use			NA			Included with other occupancies	
13 (12-1 pm)				100	100	100									
14 (1-2 pm)				100	100	100									
15 (2-3 pm)				100	100	100									
16 (3-4 pm)				100	100	100									
17 (4-5 pm)				100	100	100									
18 (5-6 pm)				100	100	100									
19 (6-7 pm)				100	100	100									
20 (7-8 pm)				100	100	100									
21 (8-9 pm)				100	100	100									
22 (9-10 pm)				100	100	100									
23 (10-11 pm)				100	100	100									
24 (11-12 am)				100	100	100									
Total/Day				2400	2400	2400									
Total/Week						168 hours									
Total/Year						8760 hours									

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2G
Restaurant Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	15	30	20	15	20	20	On	On	On	20	20	25	0	0	0
2 (1-2 am)	15	25	20	15	15	15	On	On	On	15	15	20	0	0	0
3 (2-3 am)	5	5	5	15	15	15	On	On	On	15	15	20	0	0	0
4 (3-4 am)	0	0	0	15	15	15	Off	Off	Off	0	0	0	0	0	0
5 (4-5 am)	0	0	0	15	15	15	Off	Off	Off	0	0	0	0	0	0
6 (5-6 am)	0	0	0	20	15	15	Off	Off	Off	0	0	0	0	0	0
7 (6-7 am)	0	0	0	40	30	30	Off	Off	Off	0	0	0	0	0	0
8 (7-8 am)	5	0	0	40	30	30	On	Off	Off	60	0	0	0	0	0
9 (8-9 am)	5	0	0	60	60	50	On	Off	Off	55	0	0	0	0	0
10 (9-10 am)	5	5	0	60	60	50	On	On	Off	45	50	0	0	0	0
11 (10-11 am)	20	20	10	90	80	70	On	On	On	40	45	50	0	0	0
12 (11-12 pm)	50	45	20	90	80	70	On	On	On	45	50	50	0	0	0
13 (12-1 pm)	80	50	25	90	80	70	On	On	On	40	50	40	0	0	0
14 (1-2 pm)	70	50	25	90	80	70	On	On	On	35	45	40	0	0	0
15 (2-3 pm)	40	35	15	90	80	70	On	On	On	30	40	30	0	0	0
16 (3-4 pm)	20	30	20	90	80	70	On	On	On	30	40	30	0	0	0
17 (4-5 pm)	25	30	25	90	80	60	On	On	On	30	35	30	0	0	0
18 (5-6 pm)	50	30	35	90	90	60	On	On	On	40	40	40	0	0	0
19 (6-7 pm)	80	70	55	90	90	60	On	On	On	55	55	50	0	0	0
20 (7-8 pm)	80	90	65	90	90	60	On	On	On	60	55	50	0	0	0
21 (8-9 pm)	80	70	70	90	90	60	On	On	On	50	50	40	0	0	0
22 (9-10 pm)	50	65	35	90	90	60	On	On	On	55	55	50	0	0	0
23 (10-11 pm)	35	55	20	50	50	50	On	On	On	45	40	40	0	0	0
24 (11-12 am)	20	35	20	30	30	30	On	On	On	25	30	20	0	0	0
Total/Day	750	740	485	1455	1365	1115	2000	1800	1700	790	730	625	0	0	0
Total/Week		49.75 hours			97.55 hours			135 hours			53.05 hours				0 hours
Total/Year		2594 hours			5086 hours			7039 hours			2766 hours				0 hours

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2H
Retail Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	0	0	0	5	5	5	Off	Off	Off	4	11	7	0	0	0
2 (1-2 am)	0	0	0	5	5	5	Off	Off	Off	5	10	7	0	0	0
3 (2-3 am)	0	0	0	5	5	5	Off	Off	Off	5	8	7	0	0	0
4 (3-4 am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0
5 (4-5 am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0
6 (5-6 am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0
7 (6-7 am)	0	0	0	5	5	5	On	On	Off	4	7	7	0	0	0
8 (7-8 am)	10	10	0	20	10	5	On	On	Off	15	20	10	12	9	0
9 (8-9 am)	20	20	0	50	30	10	On	On	On	23	24	12	22	21	0
10 (9-10 am)	50	50	10	90	60	10	On	On	On	32	27	14	64	56	11
11 (10-11 am)	50	60	20	90	90	40	On	On	On	41	42	29	74	66	13
12 (11-12 pm)	70	80	20	90	90	40	On	On	On	57	54	31	68	68	35
13 (12-1 pm)	70	80	40	90	90	60	On	On	On	62	59	36	68	68	37
14 (1-2 pm)	70	80	40	90	90	60	On	On	On	61	60	36	71	69	37
15 (2-3 pm)	70	80	40	90	90	60	On	On	On	50	49	34	72	70	39
16 (3-4 pm)	80	80	40	90	90	60	On	On	On	45	48	35	72	69	41
17 (4-5 pm)	70	80	40	90	90	60	On	On	On	46	47	37	73	66	38
18 (5-6 pm)	50	60	20	90	90	40	On	On	Off	47	46	34	68	58	34
19 (6-7 pm)	50	20	10	60	50	20	On	On	Off	42	44	25	68	47	3
20 (7-8 pm)	30	20	0	60	30	5	On	On	Off	34	36	27	58	43	0
21 (8-9 pm)	30	20	0	50	30	5	On	On	Off	33	29	21	54	43	0
22 (9-10 pm)	0	10	0	20	10	5	Off	On	Off	23	22	16	0	8	0
23 (10-11 pm)	0	0	0	5	5	5	Off	Off	Off	13	16	10	0	0	0
24 (11-12 am)	0	0	0	5	5	5	Off	Off	Off	8	13	6	0	0	0
Total/Day	720	750	280	1115	985	525	1500	1600	900	662	690	459	844	761	288
Total/Week		46.30 hours			70.85 hours			100 hours			44.59 hours			52.69 hours	
Total/Year		2414 hours			3694 hours			5214 hours			2325 hours			2747 hours	

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2I
School Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
2 (1-2 am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
3 (2-3 am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
4 (3-4 am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
5 (4-5 am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
6 (5-6 am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
7 (6-7 am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
8 (7-8 am)	5	0	0	30	5	5	On	Off	Off	10	3	3	0	0	0
9 (8-9 am)	75	10	0	85	15	5	On	On	Off	34	3	5	30	0	0
10 (9-10 am)	90	10	0	95	15	5	On	On	Off	60	5	5	30	0	0
11 (10-11 am)	90	10	0	95	15	5	On	On	Off	63	5	5	30	0	0
12 (11-12 pm)	80	10	0	95	15	5	On	On	Off	72	5	5	30	0	0
13 (12-1 pm)	80	10	0	80	15	5	On	On	Off	79	5	5	30	0	0
14 (1-2 pm)	80	0	0	80	5	5	On	Off	Off	83	3	5	30	0	0
15 (2-3 pm)	80	0	0	80	5	5	On	Off	Off	61	3	3	30	0	0
16 (3-4 pm)	45	0	0	70	5	5	On	Off	Off	65	3	3	15	0	0
17 (4-5 pm)	15	0	0	50	5	5	On	Off	Off	10	3	3	0	0	0
18 (5-6 pm)	5	0	0	50	5	5	On	Off	Off	10	3	3	0	0	0
19 (6-7 pm)	15	0	0	35	5	5	On	Off	Off	19	3	3	0	0	0
20 (7-8 pm)	20	0	0	35	5	5	On	Off	Off	25	3	3	0	0	0
21 (8-9 pm)	20	0	0	35	5	5	On	Off	Off	22	3	3	0	0	0
22 (9-10 pm)	10	0	0	30	5	5	On	Off	Off	22	3	3	0	0	0
23 (10-11 pm)	0	0	0	5	5	5	Off	Off	Off	12	3	3	0	0	0
24 (11-12 am)	0	0	0	5	5	5	Off	Off	Off	9	3	3	0	0	0
Total/Day	710	50	0	990	170	120	1500	500	0	691	80	84	285	0	0
Total/Week		36.00 hours			52.40 hours			80.00 hours			36.19 hours			14.25 hours	
Total/Year		1877 hours			2732 hours			4171 hours			1887 hours			743 hours	

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.2J
Warehouse Occupancy[1]

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	0	0	0	5	5	5	Off	Off	Off	2	2	2	0	0	0
2 (1-2 am)	0	0	0	5	5	5	Off	Off	Off	2	2	2	0	0	0
3 (2-3 am)	0	0	0	5	5	5	Off	Off	Off	2	2	2	0	0	0
4 (3-4 am)	0	0	0	5	5	5	Off	Off	Off	2	2	2	0	0	0
5 (4-5 am)	0	0	0	5	5	5	Off	Off	Off	5	2	2	0	0	0
6 (5-6 am)	0	0	0	5	5	5	Off	Off	Off	7	2	2	0	0	0
7 (6-7 am)	0	0	0	5	5	5	Off	Off	Off	7	2	2	0	0	0
8 (7-8 am)	15	0	0	40	5	5	On	Off	Off	10	2	2	0	0	0
9 (8-9 am)	70	20	0	70	8	5	On	On	Off	30	6	2	0	0	0
10 (9-10 am)	90	20	0	90	24	5	On	On	Off	36	12	2	0	0	0
11 (10-11 am)	90	20	0	90	24	5	On	On	Off	36	12	2	30	0	0
12 (11-12 pm)	90	20	0	90	24	5	On	On	Off	46	17	2	0	0	0
13 (12-1 pm)	50	10	0	80	5	5	On	On	Off	57	4	4	0	0	0
14 (1-2 pm)	85	10	0	90	5	5	On	On	Off	43	4	4	0	0	0
15 (2-3 pm)	85	10	0	90	5	5	On	On	Off	38	2	2	0	0	0
16 (3-4 pm)	85	10	0	90	5	5	On	On	Off	40	2	2	40	0	0
17 (4-5 pm)	20	0	0	90	5	5	On	Off	Off	30	2	2	0	0	0
18 (5-6 pm)	0	0	0	30	5	5	Off	Off	Off	18	2	2	0	0	0
19 (6-7 pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
20 (7-8 pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
21 (8-9 pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
22 (9-10 pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
23 (10-11 pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
24 (11-12 am)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
Total/Day	680	120	0	915	180	120	1000	800	0	429	91	52	70	0	0
Total/Week		35.20 hours			48.75 hours			58.00 hours			22.88 hours			3.50 hours	
Total/Year		1835 hours			2542 hours			3024 hours			1193 hours			182 hours	

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. **These values may be used only if actual schedules are not known.**

TABLE 806.3.3
HVAC Systems of Prototype Buildings[3]

Use	System #	Remarks
1. Assembly		
a. Churches (any size)	1	
b. ≤ 50,000 ft^2 or ≤ 3 floors	1 or 3	Note 2
c. > 50,000 ft^2 or > 3 floors	3	
2. Health		
a. Nursing Home (any size)	2	
b. ≤ 15,000 ft^2	1	
c. > 15,000 ft^2 and ≤ 50,000 ft^2	4	Note 3
d. > 50,000 ft^2	5	Note 3,4
3. Hotel/Motel		
a. ≤ 3 Stories	2	Note 6
b. > 3 Stories	6	Note 7
4. Light Manufacturing	1 or 3	
5. Office		
a. ≤ 20,000 ft^2	1	
b. > 20,000 ft^2 and either ≤ 3 floors or ≤ 75,000 ft^2	4	
c. > 75,000 ft^2 or > 3 floors	5	
6. Restaurant	1 or 3	Note 2
7. Retail		
a. ≤ 50,000 ft^2	1 or 3	Note 2
b. > 50,000 ft^2	4 or 5	Note 2
8. Schools		
a. ≤ 75,000 ft^2 or ≤ 3 floors	1	
b. > 75,000 ft^2 or > 3 floors	3	
9. Warehouse		Note 5

Footnote to Table 3-3: The systems and energy types presented in this table are not intended as requirements or recommendations for the proposed design. Floor areas in the table are the total conditioned floor areas for the listed use in the building. The number of floors indicated in the table is the total number of occupied floors for the listed use.

TABLE 806.3.3 (Continued)
HVAC System Descriptions for Prototype Buildings[1]

HVAC Component	System #1	System #2
System Description	Packaged rooftop single zone, one unit per zone	Packaged terminal air conditioner with space heater or heat pump, heating or cooling unit per zone
Fan system Design Supply Circulation Rate	Note 10	Note 11
Supply Fan Control	Constant volume	Fan cycles with call for heating or cooling
Return Fan Control	NA	NA
Cooling System	Direct expansion air cooled	Direct expansion air cooled
Heating System	Furnace, heat pump or electric resistance	Heat pump with electric resistance auxiliary or air conditioner with space heater
Remarks	Drybulb economizer per Section 803.3.1, heat recovery if required by Section 803.2.6	No economizer, if not required by Section 803.3.1

TABLE 806.3.3 (Continued)
HVAC System Descriptions for Prototype Buildings[1]

HVAC Component	System #3	System #4
System Description	Air handler per zone with central plant	Packaged rooftop VAV with perimeter reheat and fan-powered terminal units
Fan system Design Supply Circulation Rate	Note 10	Note 10
Supply Fan Control	Constant volume	Variable Air Volume systems with controls per Section 803.4
Return Fan Control	Constant volume	Variable Air Volume systems with controls per Section 803.4
Cooling System	Chilled water (Note 12)	Direct expansion air cooled
Heating System	Hot water (Note 13)	Hot water (Note 13) or electric resistance
Remarks	Drybulb economizer per Section 803.3.1, heat recovery if required by Section 803.2.6	Drybulb economizer per Section 803.3.1. Minimum VAV setting per Section 803.4.3 Exception 1, Supply air reset by zone of greatest cooling demand, heat recovery if required by Section 803.2.6.

TABLE 806.3.3 (Continued)
HVAC System Descriptions for Prototype Buildings[1]

HVAC Component	System #5	System #6
System Description	Built-up central VAV with perimeter reheat and fan-powered terminal units	Four-pipe fan coil per zone with central plant
Fan system Design Supply Circulation Rate	Note 10	Note 10
Supply Fan Control	VAV with air-foil centrifugal fan and AC frequency variable speed drive	Fan cycles with call for heating or cooling
Return Fan Control	VAV with air-foil centrifugal fan and AC frequency variable speed drive	NA
Cooling System	Chilled water (Note 12)	Chilled water (Note 12)
Heating System	Hot water (Note 13) or electric resistance	Hot water (Note 13) or electric resistance
Remarks	Drybulb economizer per Section 803.3.1. Minimum VAV setting per Section 803.4.3 Exception 1, Supply air reset by zone of greatest cooling demand, heat recovery if required by Section 803.2.6.	No economizer, if not required by Section 803.3.1

Numbered Footnotes for Table 806.3.3
HVAC System Descriptions for Prototype Buildings

1. The systems and energy types presented in this Table are not intended as requirements or recommendations for the proposed design.
2. For occupancies such as restaurants, assembly and retail that are part of a mixed use building which, according to Table 806.3.3, includes a central chilled water plant (systems 3, 5, or 6), chilled water system type 3 or 5 shall be used as indicated in the table.
3. Constant volume may be used in zones where pressurization relationships must be maintained by code. Where constant volume is used, the system shall have heat recovery if required by Section 803.2.6. VAV shall be used in all other areas, in accordance with Section 803.4.
4. Provide run-around heat recovery systems for all fan systems with a minimum outside air intake greater than 70%. Recovery effectiveness shall be 0.50.
5. If a warehouse is not intended to be mechanically cooled, both the standard and proposed designs shall be calculated assuming no mechanical cooling.
6. The system listed is for guest rooms only. Areas such as public areas and back-of-house areas shall be served by system 4. Other areas such as offices and retail shall be served by systems listed in Table 806.3.3 for these occupancy types.
7. The system listed is for guest rooms only. Areas such as public areas and back-of- house areas shall be served by system 5. Other areas such as offices and retail shall be served by systems listed in Table 806.3.3 for these occupancy types.
8. Reserved.
9. Reserved.
10. Design supply air circulation rate shall be based on a supply-air to room-air temperature difference of 20°F. A higher supply-air temperature may be used if required to maintain a minimum circulation rate of 4.5 air changes per hour or 15 cfm per person to each zone served by the system, at design conditions. If return fans are specified, they shall be sized for the supply fan capacity less the required minimum ventilation with outside air, or 75% of the supply fan capacity, whichever is larger. Except where noted, supply and return fans shall be operated continuously during occupied hours.
11. Fan energy when included in the efficiency rating of the unit as defined in Section 803.2.3, need not be modeled explicitly for this system. The fan shall cycle with calls for heating or cooling.
12. Chilled water systems shall be modeled using a reciprocating chiller for systems with total cooling capacities less than 175 tons, and centrifugal chillers for systems with cooling capacities of 175 tons or greater. For systems with cooling capacities of 600 tons or more, the standard design energy consumption shall be calculated using two centrifugal chillers, lead/lag controlled. Chilled water shall be assumed to be controlled at a constant 44°F. Chiller water pumps shall be sized using a 12°F temperature rise, from 44°F to 56°F, operating at 65% combined impeller and motor efficiency. Condenser water pumps shall be sized using a 10°F temperature rise, operating at 60% combined impeller and motor efficiency. The cooling tower shall be an open circuit, centrifugal blower type sized for the larger of 85°F leaving water temperature or 10°F approach to design wet bulb temperature. The tower shall be controlled to provide a 65°F leaving water temperature whenever weather conditions permit, floating up to design leaving water temperatures at design conditions. Chilled water supply temperature shall be reset in accordance with Section 803.4.11.4.
13. Hot water system shall include a natural draft fossil fuel or electric boiler. The hot water pump shall be sized based on a 30°F temperature drop, from 180°F to 150°F, operating at a combined impeller and motor efficiency of 60%. Hot water supply temperature shall be reset in accordance with Section 803.4.11.4.

SECTION 806.4 SUGGESTED SOFTWARE FOR SYSTEMS ANALYSIS APPROACH

Blast 3.0 (Level 334)
Blast Support Office
University of Illinois
Dept. of Mechanical and Industrial Engineering
1206 W. Green Street, Room 140, MEB
Urbana, IL 61801
(217) 244-8182

DOE 2.1E
Energy Science Technology Software Center (ESTSC)
PO Box 1220
Oakridge, TN 37831-1020
(423) 576-2606

DOE 2.1E or DOE 2.2
James J. Hirsch & Associates
Building Performance Analysis
Software & Consulting
12185 Presilla Road
Camarillo, CA 93012-9243
(805) 532-1045

EnergyPlus
Kathy Ellington
Lawrence Berkeley National Laboratory (LBNL)
Building 90, Room 3147
Berkeley, CA 94720-0001
(510) 486-5711

ESAS
Ross Meriweather Consulting, Engineering
3315 Outrider
San Antonio, TX 78247-4405
(210) 490-7081

ESP-II
Automated Procedures for Engineering Consultants, Inc.
40 W Fourth Centre, Suite 2100
Dayton, OH 45402
(937) 228-2602

HAP 3.24
Carrier Building Systems and Services
3215 S 116th Street, Suite 133
Tukwila, WA 98168
(206) 439-0097

Trace 600 Version 18.11 or Trace 700
The Trane Co.
3600 Pammel Creek Rd.
Lacrosse, WI 54601
(608) 787-3926

Summary of Components of the "Best of the Region" Standard for New Non-Residential Buildings

Adapted from:

Northwest Energy NWBest Project Summary of Components of the "Best of the Region" Standard

Prepared by: Ecotope July 2005

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1. Introduction

In the summer of 2005, the Northwest Energy Efficiency Alliance ("Alliance") contracted with Ecotope to identify the provisions to be included in a voluntary standard that would serve to provide the region with a developed strategy to increase the most demanding provisions of existing energy codes by at least 15 percent. This strategy was divided into two primary goals:

- Phase I: Develop a "Best of Region" voluntary standard in the format of an energy code to serve as the evaluation baseline for the NWBest voluntary standard. This standard is designed to capture the most stringent regional requirements for each component.

- Phase II: Develop a NWBest standard that extends the Best of Region standard to achieve at least 15% more efficiency.

A group of regional code experts from all four states, the NWBest Technical Working Group (TWG), was convened to provide input to the development of the model standards using a consensus approach. The recommendations and alterations agreed to by the TWG have been included in this report. Appendix A lists the members of this TWG.

This interim report summarizes the components of the "Best of Region" base standard as developed by Ecotope and approved by the TWG. To develop this standard, Ecotope reviewed the most widely enforced regional codes, including the Washington and Oregon State Energy Codes (WSEC and OSEC), the Seattle Energy Code (SEC), and the International Energy & Conservation Code (IECC) that is used in Montana and Idaho. These existing codes, plus some provisions from ASHRAE Standard 90, were used to develop a composite document that sets forth the best regional standard for each component of the code. The composite best-of-region model standard has been assembled in the format of IECC 2004 including similar section numbers, organization, and much of the same administrative language. The model code language is the companion document titled "Proposed Specifications for Implementation of Fifth Power Plan Model Conservation Standards for New Commercial Buildings." This paper summarizes the major elements of the best-of-region model code and identifies the source for each.

2. Non-Residential

Our review of the non-residential provisions of the region's enforced codes indicates that there is general consensus in many aspects of the code regulations. The most significant differences often reside in the exceptions and exemptions. While the City of Seattle and State of Oregon energy codes regulate aspects of buildings not regulated in the other codes, each regional code has areas where it is most stringent. Although the ASHRAE standard was not specifically included in this comparison, it has informed the development of much of the nation's energy code development, and includes particularly

well written language in some areas. Where appropriate (especially in terms of equipment type), the basic ASHRAE structure has been used for this analysis.

2.1. Non-Residential Lighting

The following provisions constitute the Best of Region lighting standard:

2.1.1. Standard Lighting Provisions

Total connected interior lighting power. The total connected interior lighting power (Watts) shall be the sum of the watts of all interior lighting equipment as defined below.

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

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

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

Line-voltage lighting track and plug-in busway. The wattage shall be the greater of the wattage of the planned/installed luminaires or 50 W/linear foot.

Exceptions to Non-Residential Lighting provisions:

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

- Specialized medical, dental and research lighting.
- Professional sports arena playing field lighting.
- Display lighting for exhibits in galleries, museums and monuments.
- Guestroom lighting in hotels, motels, boarding houses or similar buildings.
- Emergency lighting automatically off during normal building operation.
- Lighting for theatrical/television productions, and stage lighting in entertainment facilities.
- Non-permanent task lighting.
- Lighting installed within display cases that moves with cases.

Table 2.1-1. Non-Residential Interior Lighting Requirements

Item	Source Code	Source Code Stringency or Provision
Lighting Controls		
Local Switching	All	Required in space.
Maximum control zone size	WA	Enclosed spaces plus 80% of 20 amps or 5% of total floor area if>100000sf
Occupancy Sensor	OR	Required in ALL classrooms, meeting and conference rooms and offices <300sf
Sweep/automated (occ)	SEA/OR	Required in all buildings >5000sf and all office occupancies>2000sf
Max Sweep Zone size	SEC	20 amps or 5% of total floor area
Max Sweep Override Zone size	WA	5000sf or 5% of total floor are which ever is greater
Max Override Time	All	2
Daylight Zone Circuit	WA	Required near perimeter and overhead glazing.
Holiday Scheduling	IECC2003	Requires "automatic holiday scheduling feature that turns off all loads for at least 24 hours"
Continuous Dimming	OR	Required in classrooms if there is overhead glazing or if vertical glazing is >50% of the wall
Stepped Dimming	SEC	Required for all perimeter within minimum (15',F-C) of exterior wall or areas under skylights. (min 50% step)
Bi-level switching	IECC2003	Required unless occupant sensor.
Guestroom lighting		
LPD Exemptions/Adjustments[1]		
Retail - Display Case	OR or SEC	Exempt if lighting moves with display
Retail - Display Window	OR or SEC	Exempt if within 2' of display window if separated from space
Retail - Building Showcase	OR or SEC	Not exempt
Retail - Display Luminaires	OR or SEC	Up to 1.5 w/ft2 allowed above maximum LPD for ceiling mounted, bi-directionally adjustable fixtures (unless 2-point track attachment), with LED, tungsten halogen, fluorescent, or HID lamps installed.
Display/Museum Accent/Gallery	All	Exempt
Other Non-Retail Display	OR or SEC	Exempt only in lobbies
Decorative Fixtures	SEC/WA/ OR	Not exempt
Task Lighting LPD	All	Exempt

Item	Source Code	Source Code Stringency or Provision
VDT Lighting Allowance	SEC/WA/ OR	0.00 w/sf
Production Lighting (Media,Theater)	All	Exempt
Food Prep	All but WA	Not exempt
Miscellaneous Lighting		
Line Voltage Track Lighting	SEC	50 watt/lineal foot
Low Voltage Track Lighting	SEC or OR	37.5w/lf or circuit capacity
Dual Lighting Systems	All but IECC	If lockout control then highest watt system only
Tandem Wiring (minimum 2 lamps/ballast)	IECC 2003	Yes if not EB and if available pair is within 10' for recessed or 1' if surface or pendant.
Airtight Can Lights	IECC 2003	Required
Ceiling Height	WA or OR	None
Commissioning	WA or None	Controls will be tested and calibrated.
Electric Motor Efficiency	All	>1 hp & not part of equipment
Electrical		
Transformers	SEC/OR	NEMA TP-1 1996
Wire Sizing	None	

Table 2.1-2. Non-Residential Exterior Lighting Requirements

Building or Space Use	Source Code	Base Level
Open Parking	SEC	0.15 W/ft^2
Outdoor Area	SEC	0.15 W/ft^2
Façade Area	SEC	0.15 W/ft^2 (use illuminated area only)
Perimeter	SEC	7.50 W/ft^2 (use illuminated perimeter only)
Covered Parking	SEC	0.20 W/ft^2 (or 0.30 W/ft^2 if paint reflective)
Non-Sales Canopy	SEC	No special allotment
Sales Canopy (service station)	SEC	1.00 W/ft^2
Exterior Lighting Controls	All	Automatic time switching or photocell.

Table 2.1-3. Non-Residential Interior Lighting Power Density

Building Area Type	(W/ft2)	Source
Automotive Facility	0.9	OR
Convention Center	1.2	IECC
Court House	1.2	IECC
Dining: Cafeteria/Fast Food	1.4	OR
Dining: All Other	1.0	WA
Dormitory	1.0	IECC
Exercise Center	1.0	WA
Gymnasium/Auditorium	1.0	WA
Healthcare-Clinic	1.0	OR
Hospital/Nursing Home	1.2	OR
Hotel, Common	1.0	IECC
Library	1.3	OR
Manufacturing (<20' height)	1.2	IECC
Manufacturing (>20' height)	1.5	WA
Motel	1.0	OR
Motion Picture Theater	1.0	WA
Multi-Family, Common Area	0.7	WA
Museum	1.1	IECC
Office	1.0	All
Penitentiary	1.0	IECC
Performing Arts Theater	1.0	WA
Police Station	1.0	All
Fire Station	0.8	OR
Post Office	1.1	OR
Religious Building	1.0	WA
Retail	1.5+1.5	WA,OR
School/University	1.1	OR
Sports Arena	1.0	WA
Transportation Terminals	1.0	IECC
Warehouse	0.8	OR
Workshop	1.4	OR

2.2. Non-Residential Opaque Envelope Provisions

For the envelope provisions, the Best of the Region standard divides the Northwest into two zones using a 6000 heating degree day guideline. All spaces shall be considered conditioned spaces, and shall comply with the requirements in Table 2.2-1 unless they meet the following criteria for semi-heated spaces:

- The installed heating equipment output, in Climate Zone 1, shall be 3 Btu/(h • ft^2) or greater but not greater than 8 Btu/(h • ft^2) and in Climate Zone 2, shall be 5 Btu/(h • ft^2) or greater but not greater than 12 Btu/(h • ft^2).
- Heating shall be controlled by a thermostat mounted not lower than the heating unit and capable of preventing heating above 44°F space temperature. Semi-heated spaces shall be exempt from the exterior wall insulation requirements.

Table 2.2-1. Non-Residential Opaque Envelope Requirements

Component	Source Code	Zone One	Zone Two
Roof/Ceiling			
Attic Nom Ins	WA	R30	R38
Attic U-value	WA	0.036	0.031
Roof Nom Ins	IECC/WA	R21	R25
Roof U-value	WA	0.046	0.039
Roof Deck R-value	WA	R21	R25
Roof Deck U-value	WA	0.046	0.039
Metal Roof Nom Ins	IECC2003	R30 with thermal block[1]	R30 with thermal block[1]
Metal Roof U-value	WA	0.046	0.039
Walls			
Wall Nom Ins	WA	R19	R24
Wall U-value	WA	0.062	0.044
Metal Frame Wall Nom Ins	SCL	R13+R3.8ci	R13+R3.8ci
Metal Frame Wall U-value	WA	0.084	0.084
BG Wall Nom Ins	SCL	R12	R12
BG Wall U-value	WA	0.061	0.061
Metal Wall Nom Ins	WA	R13+R13	R13+R13
Metal Wall U-value	WA		
Mass Criteria	OR	Individual walls > 45lbs/sf	Individual walls > 45lbs/sf
Mass Wall Nom Ins	WA	R5.7ci[2]	R7.6ci[2]
Mass Wall U-value	WA	0.07	0.07
Mass Wall Interior Nom R		AG[4] Wall values	AG Wall values

Component	Source Code	Zone One	Zone Two
CMU integral R	IECC	Filled cores +R5continuous or R11 framed	Filled cores +R5 continuous or R11 framed
CMU integral U			
Doors			
Door U-value	WA	Hinged <4' wide U0.6 , all other U0.2	Hinged <4' wide U0.6 , all other U0.2
Door (rollup) U-value	OR	0.2	0.2
Floors			
Floor Nom Insulation	IECC	R19	R25
Floor U-value[1]	IECC	0.045	0.035
Slab Nom Insulation	WA	R10 for 2'	R10 for 2'
Slab F value		0.54	0.54
Mass Floor ext insulation	WA	R19	R25
Heated Slab	WA	R10 for 3'	R10 for 3'
Semi-Heated			
Criteria	OR	None	None
Treatment	OR	No special treatment	No special treatment

1. Not including buffer effects from adjacent unheated spaces.
2. Thermal blocks are a minimum R-5 of rigid insulation, which extends 1" beyond the width of the purlin on each side, perpendicular to the purlin.
3. R-5.7 ci may be substituted with concrete block walls complying with A5TM C90, ungrouted or partially grouted at 32 in. or less on center vertically and 48 in. or less on center horizontally, with ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu-in./h-f F.
4. Above Grade

2.3. Non-Residential Glazing Provisions

The glazing requirements for non-residential construction are presented in the following table:

Table 2.3-1. Non-Residential Glazing Requirements

Component	Zone One		Zone Two	
	U Value	SHGC	U Value	SHGC
Site- or Factory-Built Windows (OR)				
0-25%	0.54	0.5	0.5	0.5
25%-30%	0.54	0.5	0.37	0.5
30%-40%	0.37	0.4	0.37	0.4

2.4. Non-Residential Mechanical System Equipment Provisions

Simple systems may be used if all of the following conditions are met. Otherwise, the complex system requirements should be followed.

Simple System Requirements:

Building is:
less than 3 stories
less than 25000sf

Equipment:
Is single zone split or package
Has air- or evaporatively-cooled condensers
has minimum OA of less than 3000 cfm
has less than 70% min OA or heat recovery

Table 2.4-1. Non-Residential Mechanical System Requirements

Item	Source Code	Base Level
Economizer		
Maximum DX Capacity Without Economizer	SEC2004	20 kBtuH, unless equipment is not near exterior, then 54 kBtuH
Total Capacity of Units Without Economizer	SEC2004	240 kBtuH or 10%
Important Exceptions to Economizer requirement.	IECC2004	None
DX-Economizer Integration	All Codes	Required where economizer required.
Waterside Economizer	IECC2004	100% at 50Fdb/45Fwb
HP Loop Economizer	IECC2004	Not mentioned separately. Economizer Required.
Ducts		
Duct sealing – Exterior	OR	All joints, seams, and connections
Duct sealing - Vented	OR	All joints, seams, and connections
Duct sealing – Unconditioned	OR	All joints, seams, and connections
Duct sealing – Conditioned	OR	All joints, seams, and connections
Leak Testing	IECC2004	Required if sp>3"
Duct Insulation – Exterior	OR	Supply Zone 1 - R8, Zone 2 - R12 Return Zone 1 - R6, Zone 2 - R8
Duct Insulation – Vented	WA2004	Supply/Return R7
Duct Insulation – unconditioned	WA2004	Supply/Return R7
Duct Insulation – Conditioned	WA2004	Supply/Return R3.3

Item	Source Code	Base Level
System Documentation		
Commissioning Report	WA/SEC	Preliminary commissioning report required for occupancy
Commissioning Tests Delineated	WA/SEC	"All modes as described in the sequence of operation"
Ongoing trending		None
Equipment Efficiency		
DX Cooling	Oregon	ASHRAE Oct 2001 thru 2007, then better
Chillers	SEC	different structure but partload ~5% better than ASHRAE
Furnace	All	ASHRAE Oct 2001
Unit Heater	All	ASHRAE Oct 2001
Boiler	ASHRAE	ASHRAE Oct 2001
Furnace control	ASHRAE	ASHRAE Oct 2001
Boiler control	IECC2004	Modulating or staged if cap>500kbtu
Variable Speed Drives		
VSD - fan motors	SEC/OR/WA	Required on motors>=10hp with variable loads.
VSD - pump motors	OR/IECC2004	All motors on hydronic heating loops over 10hp and all 10hp motors with variable loads
VSD or Two speed on cooling tower	OR	Required
ECM Motors	SEC	Required in VAV series terminals
Controls		
Basic Thermostat Capabilities		7 day programmable, battery backed, manual override
Heat pumps	All	Thermostat must minimize auxiliary heat on startup
Humidity Controls		
DDC Required		Not specified
Sensor Specifications		Not specified
Supply Air Temp Reset	WA/OR	Required in multi-zone systems
Supply Water Temp Reset	WA/OR	Required if capacity>300kBtu
Pressure Reset	WA/OR	Required if DDC fan powered boxes
Optimum Start	WA/OR	Required for systems >10000cfm
Maximum Control Zone Size	WA/SEC	1 floor or 1 system, whichever is smaller
Minimum Dead Band	All	5F
0% OA in Unoccupied/Warm-Up etc	OR	Yes
CO^2 Control	OR	If OA >1500cfm and occupant density>100 per 1000sf

Item	Source Code	Base Level
Cooling Tower		
Cooling Tower Approach	WA	86F condensate return
Cooling Tower Efficiency – Air	All	176000 Btu/h-hp
Cooling Tower Efficiency - Axial Fan	WA	Not specified
Cooling Tower Efficiency - Cent Fan	WA	Not specified
System Requirements		
Fume Hood VAV/HR/ or compensating	All	If OA>70%: Fume hood systems<15000cfm or labs systems with VAV or compensating hoods
Kitchen Hood	IECC2004	If OA>70%: HR or 75% compensating if >5000cfm
Fan System Efficiency	OR	Complex system path requires VAV with BHP<0.00145hp/cfm, and CV BHP <0.00104hp/cfm if total fan power is greater than 7.5HP. Complex system is any VAV system, or split CV equipment >54 kBtuH. It does not include constant volume package equipment of any size.
Motor Efficiency	All	ASHRAE table
Constant Volume VSD	OR	Systems >15000 cfm required to have two-speed operation
Air System Heat Recovery (except labs with VAV systems & kitchen hoods)	WA	Any system >5000cfm with >70%OA
Condenser Heat Recovery	WA/IECC	If 24hr facility, reject capacity is >6 million Btu, and h2o cap>1 million Btu.
Motorized air inlet, outlet, and relief dampers	WA/OR	Required in buildings over 2 stories
Elevator/Stairwell smoke relief openings	WA/OR	Normally open dampers required
HP Loop unit valves	OR	Required if total circulating pump power >10hp
HP Loop tower bypass	OR	Required
Heat pump required	WA/SEC	If package or split system electric heat/cool unit with DX capacity >20kBtuh
Three-pipe systems	IECC2004	Not allowed.
Two-pipe change over control requirements	IECC	Controls must allow 15F OAT deadband for changeover, have minimum 4 hour operation before changeover, and allow maximum 30F heating water to cooling water differential.
Heat pump loop control requirements	IECC	Controls must allow min 20F deadband for circulating water
Pump isolation on multiple chiller systems	IECC	Required

2.5. Non-Residential Performance Standard

All regional non-residential energy codes include a performance-based standard as an alternative to the prescriptive and component standards outlined in sections 2.1 through 2.4 above. The composite best-of-region standard uses the Washington reference standard RS 29, with the Seattle amendments, as the source code for the performance-based standard. This language was selected as the best in the region because it is based on energy rather than energy cost, has more specificity in the energy modeling assumptions and methodologies, and is simpler than the performance-based standards in the existing codes of Idaho, Oregon, and Montana or from ASHRAE.

APPENDIX A: Technical Advisory Group Member Roster

Name	Organization
Ken Baker	Baker Energy
David Cohen	Northwest Energy Efficiency Alliance
Pam Cole	Pacific Northwest National Lab
Craig Conner	Building Quality
Charlie Grist	Northwest Power Planning Council
Jeff Harris	Northwest Energy Efficiency Alliance
John Hogan	Seattle Energy Code Council
Michael Lane	Lighting Design Lab
Eric Makela	Britt/Makela Group
Chuck Murray	WSU Cooperative Extension Energy Program
Stan Price	Washington Energy Code Council
Michael Rosenberg	Oregon Department of Energy
Alan Seymour	Oregon Department of Energy
Diana Shankle	Pacific Northwest National Lab
Todd Taylor	Pacific Northwest National Lab
Paul Tschida	Montana State Energy Office

APPENDIX B: Non-Residential Prescriptive Lighting Examples

Prescriptive Path fluorescent lamp requirements (only for spaces with maximum code LPD levels greater than 0.8w/sf)	WA or None	1 or 2 lamp, non-lensed fluorescent, reflector, T1-T8, hard-wired electronic dimming ballast with controls
Prescriptive metal halide lamp requirements (only for spaces with maximum code LPD levels greater than 0.8w/sf)	WA or None	Must have reflector/louver fitted with <150 watt ceramic metal halide with electronic ballast. All other MH are limited, along with other ballasted fixtures, to 5% of the total fixture count.

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