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The City of Seattle – Legislative Department

Clerk File sponsored by: Clark

2009 Washington State Energy Code.

Related Legislation File: CB. 116967

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10.18.10	

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Date Filed with City Clerk

Emilia M. Sanchez

By

Committee Action:

Date	Recommendation	Vote

This file is complete and ready for presentation to Full Council.

Full Council Action:

Date	Decision	Vote
10.18.10	Filed	9-0

Law Department

CF No.311044

Title:2009 Washington State Energy Code.

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WASHINGTON STATE ENERGY CODE
2009 EDITION

CHAPTER 51-11 WAC

WASHINGTON STATE BUILDING CODE COUNCIL

EFFECTIVE JULY 1, 2010

NOTE ON DELAYED EFFECTIVE DATE:

The Washington State Building Code Council has delayed the effective date of this Code to October 29, 2010 (WSR 10-13-113, June 21, 2010). In July 2010 the Council proposed an amendment to further delay the effective date to January 1, 2011, and stated that it intended to act on that amendment on October 15, 2010 (WSR 10-14-111).

Copies of the State Building Codes and
complete copies of the 2009 International Building Code
as published by the International Code Council
may be obtained from:

Washington Association of Building Officials
Post Office Box 7310
Olympia, Washington 98507-7310
(360) 586-6725 www.wabo.org
or toll free in Washington State at (888) 664-9515

First Edition
2009 Washington State Energy Code
Effective July 1, 2010
Printed April 2010

First Edition based on
WSR 10-03-115

Chapter 51-11 WAC

PREFACE

Authority: The Washington State Energy Code (Chapter 51-11 WAC) is adopted by the Washington State Building Code Council pursuant to Chapter 19.27A.020. This code provides a minimum level of energy efficiency, but allows flexibility in building design, construction and heating equipment efficiencies. The design of this code allows space heating equipment efficiencies to offset or substitute for building envelope thermal performance.

The 2009 Washington State Energy Code (WSEC) amends the 2006 WSEC, Chapter 51-11 WAC, as published in the Washington State Administrative Code.

Code Precedence: The State Building Code Act, Chapter 19.27 RCW, establishes the following order of precedence among the documents adopted as parts of the State Building Code:

International Building Code, Standards and amendments – WAC 51-50;
International Residential Code, Standards and amendments – WAC 51-51;
International Mechanical Code, Standards and amendments – WAC 51-52;
International Fire Code, Standards and amendments – WAC 51-54;
Uniform Plumbing Code, Standards and amendments - WAC 51-56, 51-57.

Where there is a conflict between codes, an earlier named code takes precedence over a later named code. In the case of conflict between the duct insulation requirements of the International Mechanical Code and the duct insulation requirements of the Energy Code, the Energy Code, or where applicable, a local jurisdiction's energy code, shall govern.

Where, in any specific case, different sections of this Code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

Enforcement: The State Building Code Act requires that each local jurisdiction enforce the State Building Code within its jurisdiction. Any jurisdiction can contract with another jurisdiction or an inspection agency to provide the mandated enforcement activities.

Amendments to the State Building Code: The State Building Code Council has adopted review procedures and approval criteria for local amendments. These procedures and criteria are found in Chapter 51-04 WAC. The Council has exempted from its review any amendments to the administrative provisions of the various codes.

Forms for proposing statewide amendments to the State Building Code are available from the State Building Code Council staff.

A. **Amendments of Statewide Application**: On a yearly basis the State Building Code Council will consider proposals to amend the State Building Code. Unless directed by the State Legislature, federal mandates or court order, the Council will not enter formal rulemaking until 2012 as part of its consideration of adoption of the 2012 series of codes.

   Proposals to amend the State Building Code shall be made on forms provided by the Building Code Council.

   Code Change Proposal Submittal Deadline: March 1st of each year.

B. **Local Amendments**: Any jurisdiction may amend the State Building Code provided the amendments do not reduce the minimum performance standards of the codes. There are two areas where local amendments are limited or prohibited:

Prohibited Amendments: Residential provisions of the State Energy Code (WAC 51-11), the Ventilation and Indoor Air Quality Code (WAC 51-13); any provision of the International Building Code or International Residential Code affecting accessibility; and standards specifically adopted in Chapters 19.27 and 19.27A RCW cannot be amended by any local jurisdiction.

Residential Amendments: Amendments by local jurisdictions which affect the construction of single family and multi-family residential buildings must be reviewed and approved by the State Building Code Council before such amendments can be enforced. The State Building Code Act provides the following definition:

> **Multi-family residential building:** means common wall residential buildings that consist of four or fewer units, that do not exceed two stories in height, that are less than 5,000 square feet in area, and that have a one-hour fire-resistive occupancy separation between units.

Application forms for Council review of local amendments are available from the State Building Code Council Staff or can be found on our web site:

Washington State Building Code Council
Post Office Box 42525
Olympia, Washington 98504-42525
www.sbcc.wa.gov
(360) 725-2967 Fax (360) 586-9383
e-mail: sbcc@cted.wa.gov

Effective Date: These rules were adopted by the State Building Code Council on November 20, 2009. The rules are effective throughout the state on July 1, 2010. (This version of the code is based on WAC 51-11 as published in WSR 10-03-115. It is subject to review by the State Legislature during the 2010 session.)

Building Permit Fees: The activities of the State Building Code Council are supported by permit fees collected by each city and county. Section 19.27.085 of the State Building Code Act requires that a fee of $4.50 be imposed on each building permit issued by each city and county. In addition, a fee of $2.00 per unit shall be imposed for each dwelling unit after the first unit, on each building containing more than one residential unit. For the purpose of this fee, WAC 365-110-035 defines building permits as any permit to construct, enlarge, alter, repair, move, improve, remove, convert or demolish any building or structure regulated by the Building Code. Exempt from the fee are plumbing, electrical, mechanical permits, permits issued to install a mobile/manufactured home, commercial coach or factory built structure, or permits issued pursuant to the International Fire Code.

Each city and county shall remit moneys collected to the state treasury quarterly. No remittance is required until a minimum of $50.00 has accumulated.

These permit fees are the amounts current in January 2010. Such fees may be changed by the State Legislature.

Opinions: Only at the request of local enforcement official, the State Building Code Council may issue interpretations/opinions of those provisions of the State Building Code created by the Council, or provisions of the model codes amended by the Council. Final interpretation authority for any specific permit resides with the local enforcement official.

2006 WASHINGTON STATE ENERGY CODE

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CHAPTER 1
ADMINISTRATION AND ENFORCEMENT

SECTION 101 — SCOPE AND GENERAL REQUIREMENTS

101.1 Title: Chapters 1 through 10 of this Code shall be known as the "Washington State Single-Family Residential Energy Code" and may be cited as such; and will be referred to herein as "this Code."

101.2 Purpose and Intent: The purpose of this Code is to provide minimum standards for new or altered buildings and structures or portions thereof to achieve efficient use and conservation of energy.

The purpose of this Code is not to create or otherwise establish or designate any particular class or group of persons who will or should be especially protected or benefited by the terms of this Code.

It is intended that these provisions provide flexibility to permit the use of innovative approaches and techniques to achieve efficient use and conservation of energy. These provisions are structured to permit compliance with the intent of this Code by any one of the following three paths of design:

1. A systems analysis approach for the entire building and its energy-using sub-systems which may utilize renewable energy sources; Chapters 4 and 9.
2. A component performance approach for various building elements and mechanical systems and components; Chapters 5 and 9.
3. A prescriptive requirements approach; Chapters 6 and 9.

Compliance with any one of these approaches meets the intent of this Code. This Code is not intended to abridge any safety or health requirements required under any other applicable codes or ordinances.

The provisions of this Code do not consider the efficiency of various energy forms as they are delivered to the building envelope. A determination of delivered energy efficiencies in conjunction with this Code will provide the most efficient use of available energy in new building construction.

101.3 Scope: This Code sets forth minimum requirements for the design of new buildings and structures that provide facilities or shelter for residential occupancies by regulating their exterior envelopes and the selection of their mechanical systems, domestic water systems, electrical distribution and illuminating systems, and equipment for efficient use and conservation of energy.

Buildings shall be designed to comply with the requirements of either Chapter 4, 5 or 6 of this Code and the additional energy efficiency requirements included in Chapter 9 of this Code.

Spaces within the scope of Section R101.2 of the International Residential Code shall comply with Chapters 1 through 10 of this Code. All other spaces, including other Group R Occupancies, shall comply with Chapters 11 through 20 of this Code. Chapter 2 (Definitions), Chapter 7 (Standards) and Chapter 10 (Default heat loss coefficients) are applicable to all building types.

101.3.1 Exempt Buildings: Buildings and structures or portions thereof meeting any of the following criteria shall be exempt from the building envelope requirements of Sections 502 and 602, but shall comply with all other requirements for mechanical systems and domestic water systems.

101.3.1.1: Buildings and structures or portions thereof whose peak design rate of energy usage is less than 3.4 Btu/h per ft^2 or 1.0 watt per ft^2 of floor area for space conditioning requirements.

101.3.1.2: Buildings and structures or portions thereof which are neither heated according to the definition of heated space in Chapter 2, nor cooled by a non-renewable energy source, provided that the non-renewable energy use for space conditioning complies with requirements of Section 101.3.1.1.

101.3.1.3: Greenhouses isolated from any conditioned space and not intended for occupancy.

101.3.2 Application to Existing Buildings: Additions, historic buildings, changes of occupancy or use and alterations or repairs shall comply with the requirements in the subsections below.

> **EXCEPTION:** The building official may approve designs of alterations or repairs which do not fully conform with all of the requirements of this Code where in the opinion of the building official full compliance is physically impossible and/or economically impractical and:
>
> 1. The alteration or repair improves the energy efficiency of the building; or
> 2. The alteration or repair is energy efficient and is necessary for the health, safety, and welfare of the general public.

In no case shall building envelope requirements or mechanical system requirements be less than those requirements in effect at the time of the initial construction of the building.

101.3.2.1 Additions to Existing Buildings: Additions to existing buildings or structures may be made to such buildings or structures without making the entire building or structure comply, provided that the new additions shall conform to the provisions of this Code.

EXCEPTION: New additions which do not fully comply with the requirements of this Code and which have a floor area which is less than 750 square feet shall be approved provided that improvements are made to the existing occupancy to compensate for any deficiencies in the new addition. Compliance shall be demonstrated by either systems analysis or component performance calculations. The nonconforming addition and upgraded existing occupancy shall have an energy budget or Target UA which is less than or equal to the unimproved existing building (minus any elements which are no longer part of the building envelope once the addition is added), with the addition designed to comply with this Code.

101.3.2.2 Historic Buildings: The building official may modify the specific requirements of this Code for historic buildings and require in lieu thereof alternate requirements which will result in a reasonable degree of energy efficiency. This modification may be allowed for those buildings which have been specifically designated as historically significant by the state or local governing body, or listed in The National Register of Historic Places or which have been determined to be eligible for listing.

101.3.2.3 Change of Occupancy or Use: Any space not within the scope of Section 101.3 which is converted to space that is within the scope of Section 101.3 shall be brought into full compliance with this Code.

101.3.2.4 Alterations and Repairs: All alterations and repairs to buildings or portions thereof originally constructed subject to the requirements of this Code shall conform to the provisions of this Code without exception. For all other existing buildings, initial tenant alterations shall comply with the new construction requirements of this Code. Other alterations and repairs may be made to existing buildings and moved buildings without making the entire building comply with all of the requirements of this Code for new buildings, provided the requirements of Sections 101.3.2.5 through 101.3.2.8 are met.

101.3.2.5 Building Envelope: The result of the alterations or repairs both:

1. Improves the energy efficiency of the building, and

2. Complies with the overall average thermal transmittance values of the elements of the exterior building envelope in Table 5-1 of Chapter 5, or the nominal R-values and glazing requirements of the reference case in Tables 6-1 and 6-2 of Chapter 6.

EXCEPTIONS: 1. Untested storm windows may be installed over existing glazing for an assumed U-factor of 0.90, however, where glass and sash are being replaced, glazing shall comply with the appropriate reference case in Tables 6-1 and 6-2.

2. Where the structural elements of the altered portions of roof/ceiling, wall or floor are not being replaced, these elements shall be deemed to comply with this Code if all existing framing cavities which are exposed during construction are filled to the full depth with batt insulation or insulation having an equivalent nominal R-value. 2x4 framed walls shall be insulated to a minimum of R-15 and 2x6 framed walls shall be insulated to a minimum of R-21. Roof/ceiling assemblies shall maintain the required space for ventilation. Existing walls and floors without framing cavities need not be insulated. Existing roofs shall be insulated to the requirements of this Code if:

a. The roof is uninsulated or insulation is removed to the level of the sheathing, or

b. All insulation in the roof/ceiling was previously installed exterior to the sheathing or nonexistent.

101.3.2.6 Mechanical Systems: Those parts of systems which are altered or replaced shall comply with Section 503 of this Code. When a space-conditioning system is altered by the installation or replacement of space-conditioning equipment (including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, cooling or heating coil, or the furnace heat exchanger), the duct system that is connected to the new or replacement space-conditioning equipment shall be sealed, as confirmed through field verification and diagnostic testing in accordance with procedures for duct sealing of existing duct systems as specified in RS-33. The test results shall confirm at least one of the following performance requirements:

1. The measured total duct leakage shall be less than or equal to 8 percent of the conditioned floor area, measured in CFM @ 25 Pascals; or

2. The measured duct leakage to outside shall be less than 6 percent of the conditioned floor area, measured in CFM @ 25 Pascals; or

3. The measured duct leakage shall be reduced by more than 50 percent relative to the measured leakage prior to the installation or replacement of the space conditioning equipment and a visual inspection including a smoke test shall demonstrate that all accessible leaks have been sealed; or

4. If it is not possible to meet the duct requirements of 1, 2 or 3, all accessible leaks shall be sealed and verified through a visual inspection and through a smoke test by a certified third party.

EXCEPTIONS: 1. Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in RS-33.

2. Ducts with less than 40 linear feet in unconditioned spaces.

3. Existing duct systems constructed, insulated or sealed with asbestos.

101.3.2.7 Domestic Water Systems: Those parts of systems which are altered or replaced shall comply with Section 504 of this Code.

101.3.2.8: Lighting: Alterations shall comply with Sections 505 and 1132.3.

101.3.3 Mixed Occupancy: When a building houses more than one occupancy, each portion of the building shall conform to the requirements for the occupancy housed therein. Where approved by the building official, where

minor accessory uses do not occupy more than 10% of the area of any floor of a building, the major use may be considered the building occupancy.

101.4 Amendments By Local Government: Except as provided in RCW 19.27A.020(7), this Code shall be the maximum and minimum energy code for single-family residential construction in each town, city and county.

SECTION 102 — MATERIALS AND EQUIPMENT

102.1 Identification: All materials and equipment shall be identified in order to show compliance with this Code.

102.2 Maintenance Information: Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label. Such label may be limited to identifying, by title or publication number, the operation and maintenance manual for that particular model and type of product. Maintenance instructions shall be furnished for any equipment which requires preventive maintenance for efficient operation.

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

The provisions of this Code are 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 has been approved by the building official as meeting the intent of this Code. The building official may approve any such alternate provided he finds the proposed alternate meets or exceeds the provisions of this Code and that the material, method, design or work offered is for the purpose intended, at least the equivalent of that prescribed in this Code, in quality, strength, effectiveness, fire-resistance, durability, safety and efficient use and conservation of energy. The building official may require that sufficient evidence of proof be submitted to substantiate any claims that may be made regarding performance capabilities.

SECTION 104 — PLANS AND SPECIFICATIONS

104.1 General: If required by the building official, plans and specifications shall be submitted in support of an application for a building permit. If required by the building official, plans and specifications shall be stamped and authenticated by a registered design professional currently licensed in the state of Washington. All plans and specifications, together with supporting data, shall be submitted to the building official prior to issuance of a building permit.

104.2 Details: The plans and specifications shall show in sufficient detail all pertinent data and features of the building and the equipment and systems as herein governed including, but not limited to: design criteria, exterior envelope component materials, U-factors of the envelope systems, R-values of insulating materials, size and type of apparatus and equipment, equipment and systems controls and other pertinent data to indicate compliance with the requirements of this Code.

The building official may accept the professional stamp of an architect or engineer licensed to do business by the state in lieu of a plan and specification check if the engineer or architect stipulates to the best of his knowledge, understanding and belief, the design meets the requirements of this Code.

SECTION 105 — INSPECTIONS AND ENFORCEMENT

105.1 General: All construction or work for which a permit is required shall be subject to inspection by the building official and all such construction or work shall remain accessible and exposed for inspection purposes until approved by the building official.

105.2 Approvals Required: No work shall be done on any part of the building or structure beyond the point indicated in each successive inspection without first obtaining the approval of the building official.

105.2.1 Required Inspections: The building official, upon notification, shall make the following inspection in addition to those inspections required in Section 109.3 of the International Building Code:

1. **Wall Insulation Inspection:** To be made after all wall insulation and air vapor retarder sheet or film materials are in place, but before any wall covering is placed.

105.3 Reinspection: The building official may require a structure to be reinspected.

105.4 Certificate: A permanent certificate shall be posted within three feet of the electrical distribution panel. The certificate shall be completed by the builder or registered design professional. The certificate shall list the predominant R-values of insulation installed in or on ceiling/roof, walls, foundation (slab, basement wall, crawlspace wall and/or floor), and ducts outside the conditioned spaces; U-factors for fenestration; and the solar heat gain coefficient (SHGC) of fenestration. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the type and efficiency of heating, cooling, and service water heating equipment, duct leakage rates including test conditions as specified in Section 503.10.2, and air leakage results if a blower door test was conducted.

SECTION 106 — VIOLATIONS

It shall be unlawful for any person, firm, or corporation to erect or construct any building, or remodel or rehabilitate any existing building or structure in the state, or allow the same to be done, contrary to or in violation of any of the provisions of this Code.

SECTION 107 — LIABILITY

Nothing contained in this Code is intended to be nor shall be construed to create or form the basis for any liability on the part of any city or county or its officers, employees or

agents for any injury or damage resulting from the failure of a building to conform to the provisions of this Code.

SECTION 108 — CONFLICTS WITH OTHER CODES

In addition to the requirements of this Code, all occupancies shall conform to the provisions included in the State Building Code (Chapter 19.27 RCW). In case of conflicts among Codes enumerated in RCW 19.27.031 subsections (1), (2), (3) and (4) and this Code, an earlier named Code shall govern over those following. In the case of conflict between the duct sealing and insulation requirements of this Code and the duct insulation requirements of Sections 603 and 604 of the State Mechanical Code (Chapter 51-52 WAC), the duct insulation requirements of this code, or where applicable, a local jurisdiction's energy code shall govern.

Where, in any specific case, different sections of this Code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable. Wherever in this Code reference is made to the appendix, the provisions in the appendix shall not apply unless specifically adopted.

SECTION 109 — SEVERABILITY

If any provision of this Code or its application to any person or circumstance is held invalid, the remainder of this Code or the application of the provision to other persons or circumstances is not affected.

CHAPTER 2
DEFINITIONS

SECTION 201 — GENERAL DEFINITIONS

The following definitions shall apply to Chapters 1 through 20.

201.1 Application of Terms: For the purposes of this Code, certain abbreviations, terms, phrases, words and their derivatives, shall be as set forth in this chapter. Where terms are not defined, they shall have their ordinary accepted meanings within the context with which they are used. In the event there is a question about the definition of a term, the definitions for terms in the Codes enumerated in RCW 19.27.031 and the edition of Webster's dictionary referenced therein shall be considered as the sources for providing ordinarily accepted meanings.

ADDITION: See the Washington State Building Code.

ADVANCED FRAMED CEILING: Advanced framing assumes full and even depth of insulation extending to the outside edge of exterior walls. (See **Standard Framing** and Section 1007.2 of this Code.)

ADVANCED FRAMED WALLS: Studs framed on 24 inch centers with double top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and one stud is used to support each header. Headers consist of double 2x material with R-10 insulation between the header and exterior sheathing. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall. (See **Standard Framing** and Section 1005.2 of this Code.)

AFUE – ANNUAL FUEL UTILIZATION EFFICIENCY: Unlike steady state conditions, this rating is based on average usage including on and off cycling as set out in the standardized Department of Energy Test Procedures.

AHRI: Air-Conditioning, Heating and Refrigeration Institute.

AIR BARRIER: Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials.

AIR-CONDITIONING, COMFORT: The process of treating air to control simultaneously its temperature, humidity, cleanliness and distribution to meet requirements of the conditioned space.

AIR-IMPERMEABLE INSULATION: An insulation having an air permeance equal to or less than 0.02 L/s-m^2 at 75 Pa pressure differential tested in accordance with ASTM E2178 or ASTM E283.

APPROVED: Approval by the Code official as a result of investigation and tests conducted by him or her, or by reason of accepted principles, or tests by nationally recognized organizations.

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASTM: American Society for Testing and Materials.

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.**)

BELOW-GRADE WALLS: See **Walls.**

BOILER CAPACITY: The rate of heat output in Btu/h measured at the boiler outlet, at the design inlet and outlet conditions and rated fuel/energy input.

BUILDING ENTRANCE: Any doorway, set of doors, turnstile, vestibule, or other form of portal that is ordinarily used to gain access to the building by its users and occupants.

BUILDING ENVELOPE: For Single-Family residential spaces, the elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from spaces exempted by the provisions of Section 101.3.1. For Other Spaces, the elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior, or to or from unconditioned spaces, or to or from semi-heated spaces, or to or from spaces exempted by the provisions of Section 1301.

BUILDING, EXISTING: See the Washington State Building Code.

BUILDING OFFICIAL: The official authorized to act in behalf of a jurisdiction code enforcement agency or its authorized representative.

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

COLD STORAGE SPACE: Spaces that are mechanically cooled and designed to be maintained at a temperature below 45°F (7°C) and at or above 28°F (-2.2°C).

COMMISSIONING: A systematic process of verification and documentation that ensures that the selected building systems have been designed, installed and function properly, efficiently, and can be maintained in accordance with the contract documents in order to satisfy the building owner's design intent and operational requirements.

CONDITIONED FLOOR AREA: (See **Gross Conditioned Floor Area**.)

CONDITIONED SPACE: A cooled space, heated space (fully heated), heated space (semi-heated), or indirectly conditioned space, excluding cold storage spaces and frozen storage spaces.

CONTINUOUS INSULATION (c.i.): Insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

COOLED SPACE: An enclosed space within a building that is cooled by a cooling system whose sensible capacity

a. exceeds 5 Btu/(h•ft^2), or

b. is capable of maintaining space dry bulb temperature of 90°F or less at design cooling conditions.

COP – COEFFICIENT OF PERFORMANCE: The ratio of the rate of net heat output (heating mode) or heat removal (cooling mode) to the rate of total on-site energy input to the heat pump, expressed in consistent units and under designated rating conditions. (See **Net Heat Output, Net Heat Removal, Total On-Site Energy Input.**)

DAYLIGHTED ZONE:

a. **Under overhead glazing**: the area under overhead glazing whose horizontal dimension, in each direction, is equal to the overhead glazing dimension in that direction plus either 70 percent of the floor to ceiling height or the dimension to a ceiling height opaque partition, or one-half the distance to adjacent overhead or vertical glazing, whichever is least.

b. **At vertical glazing**: the area adjacent to vertical glazing which receives daylighting from the glazing. For purposes of this definition and unless more detailed daylighting analysis is provided, the primary daylighted zone depth extends into the space a distance equal to the window head height and the secondary daylighted zone extends from the edge of the primary zone to a distance equal to two times the window head height, or to the nearest ceiling height opaque partition, whichever is less. The daylighting zone width is assumed to be the width of the window plus either two feet on each side (the distance to an opaque partition) or one-half the distance to adjacent overhead or vertical glazing, whichever is least.

DAYLIGHT SENSING CONTROL (DS): A device that automatically regulates the power input to electric lighting near the glazing to maintain the desired workplace illumination, thus taking advantage of direct or indirect sunlight.

DEADBAND: The temperature range in which no heating or cooling is used.

DEMAND CONTROL VENTILATION (DCV): A ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

DESIGN COOLING CONDITIONS: The temperatures specified in Section 302.

DESIGN HEATING CONDITIONS: The temperatures specified in Section 302.

DOMESTIC WATER SYSTEM: Supply of hot water and cold water for domestic or commercial purposes other than comfort heating and cooling.

DOOR: All operable opening areas, which are not glazing, in the building envelope including swinging and roll-up doors, fire doors, smoke vents and access hatches.

DOOR AREA: Total area of door measured using the rough opening and including the door and frame.

DWELLING UNIT: See the Washington State Building Code.

ECONOMIZER, AIR: A ducting arrangement and automatic control system that allows a cooling supply fan system to supply outside air to reduce or eliminate the need for mechanical refrigeration during mild or cold weather.

ECONOMIZER, WATER: A system by which the supply air of a cooling system is cooled directly, indirectly or both, by evaporation of water or by other appropriate fluid in order to reduce or eliminate the need for mechanical refrigeration.

EER – ENERGY EFFICIENCY RATIO: The ratio of net equipment cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions.

EFFICIENCY, HVAC SYSTEM: The ratio of useful energy (at the point of use) to the energy input for a designated time period, expressed in percent.

EMISSIVITY: The ability to absorb infrared radiation. A low emissivity implies a higher reflectance of infrared radiation.

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

ENERGY, RECOVERED: (See **Recovered Energy**.)

ENERGY RECOVERY VENTILATION SYSTEM: System that employs 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.

EXTERIOR ENVELOPE: (See **Building Envelope.**)

F-FACTOR: The perimeter heat loss factor expressed in Btu/h•ft•°F.

F-VALUE: (See F-factor.)

FACADE AREA: Vertical projected area including non-horizontal roof area, overhangs, cornices, etc. measured in elevation in a vertical plane parallel to the plane of the building face.

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

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

b. **Vertical fenestration:** All fenestration other than skylights. Trombe wall assemblies, where glazing is installed within 12 inches of a mass wall, are considered walls, not fenestration. For the purposes of determining building envelope requirements, the vertical fenestration classifications are defined as follows:

i. **Metal framing:** Products with metal framing with or without thermal break.

ii. **Metal framing, entrance door:** Any doorway, set of doors, turnstile, vestibule, or other form of portal that is ordinarily used to gain access by its users and occupants to the building or to individual tenant spaces accessed from the exterior. (See also building entrance.)

iii. **Metal framing, fixed:** All vertical fenestration, other than entrance door and operable, including, but not limited to, curtain walls, window walls, fixed windows, picture windows, glass block walls, nonopenable clerestory windows, and nonopenable sidelites and transoms.

iv. **Metal framing, operable:** All vertical fenestration that opens, except entrance doors, including, but not limited to, casement windows, projecting windows, pivoting windows, horizontal sliding windows, vertical sliding windows, openable clerestory windows, openable sidelites and transoms, sliding glass doors, and doors that are not entrance doors.

v. **Nonmetal framing:** All products with framing materials other than metal with or without metal reinforcing or cladding.

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

a. **Mass floor:** A floor with a heat capacity that exceeds 7 Btu/ft^2□F or 5 Btu/ft^2□F provided that the floor has a material unit mass not greater than 120 lb/ft^3.

b. **Steel-joist floor:** A floor that is not a mass floor and has steel joist members supported by structural members.

c. **Wood-framed and other floors:** All other floor types, including wood joist floors. (See also building envelope, fenestration, opaque area and slab-on-grade floor.)

FLOOR OVER UNCONDITIONED SPACE: A floor which separates a conditioned space from an unconditioned space which is buffered from exterior ambient conditions including vented crawlspaces and unconditioned basements or other similar spaces, or exposed to exterior ambient conditions including open parking garages and enclosed garages which are mechanically ventilated.

FROZEN STORAGE SPACE: Spaces that are mechanically cooled and designed to be maintained at a temperature below 28°F (-2.2°C).

GARDEN WINDOW: A multi-sided glazing product that projects beyond the plane of the wall.

GLAZED WALL SYSTEM: A category of site assembled fenestration products used in the NFRC 100 and NFRC 200 rating procedures that include curtainwalls.

GLAZING: All areas, including the frames, in the shell of a conditioned space that let in natural light including windows, clerestories, skylights, sliding or swinging glass doors and glass block walls.

GLAZING AREA: Total area of the glazing measured using the rough opening, and including the glazing, sash and frame. For doors where the daylight opening area is less than 50 percent of the door area, the glazing area is the daylight opening area. For all other doors, the glazing area is the door area.

GROSS CONDITIONED FLOOR AREA: The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system, and which has an average height of five feet or greater, measured from the exterior faces.

GROSS EXTERIOR WALL AREA: The normal projection of the building envelope wall area bounding interior space which is conditioned by an energy-using system and which separates conditioned space from: unconditioned space, or semi-heated space, or exterior ambient conditions or earth; includes opaque wall, vertical glazing and door areas. The gross area of walls consists of

all opaque wall areas, including foundation walls, between floor spandrels, peripheral edges of floors, vertical glazing areas and door areas, where such surfaces are exposed to exterior ambient conditions and enclose a conditioned space including interstitial areas between two such spaces. The area of the wall is measured from the top of the floor insulation to the bottom of the roof insulation. (See **Below Grade Walls.**)

GROSS FLOOR AREA: The sum of the areas of the several floors of the building, including basements, cellars, mezzanine and intermediate floored tiers and penthouses of headroom height, measured from the exterior faces of exterior walls or from the center line of walls separating buildings, but excluding: Covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs and similar features.

GROSS ROOF/CEILING AREA: A roof/ceiling assembly shall be considered as all components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to exterior ambient conditions and encloses a conditioned space. The assembly does not include those components that are separated from a heated and/or cooled space by a vented airspace. The gross area of a roof/ceiling assembly consists of the total interior surface of such assembly, including overhead glazing.

GUEST ROOM: See the Washington State Building Code.

HEAT: The form of energy that is transferred by virtue of a temperature difference.

HEAT STORAGE CAPACITY: The physical property of materials (mass) located inside the building envelope to absorb, store and release heat.

HEATED SPACE (FULLY HEATED): An enclosed space within a building, including adjacent connected spaces separated by an uninsulated component (e.g., basements, utility rooms, garages, corridors), which is heated by a heating system whose output capacity is:

a. Capable of maintaining a space dry-bulb temperature of 45°F or greater at design heating conditions, or

b. 8 Btu/(h ∘ ft^2) or greater in Climate Zone 1 and 12 Btu/(h ∘ ft^2) or greater in Climate Zone 2.

HEATED SPACE (SEMI-HEATED): An enclosed space within a building, including adjacent connected spaces separated by an un-insulated component (e.g., basements, utility rooms, garages, corridors), which is:

a. heated by a heating system whose output capacity is 3 Btu/(h ∘ ft^2) or greater in Climate Zone 1 and 5 Btu/(h ∘ ft^2) or greater in Climate Zone 2,

b. not a Heated Space (Fully Heated), and

c. is not a cold storage space or frozen storage space.

HIGH EFFICACY LAMPS: Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

a. 60 lumens per watt for lamps over 40 watts;
b. 50 lumens per watt for lamps over 15 watts to 40 watts;
c. 40 lumens per watt for lamps 15 watts or less.

HIGH EFFICACY LUMINAIRE: A lighting fixture that does not contain a medium screw base socket (E24/E26) and whose lamps or other light source have a minimum efficiency of:

a. 60 lumens per watt for lamps over 40 watts;
b. 50 lumens per watt for lamps over 15 watts to 40 watts;
c. 40 lumens per watt for lamps 15 watts or less.

HSPF – HEATING SEASON PERFORMANCE FACTOR: The total heating output (Btu) of a heat pump during its normal annual usage period for heating divided by the total electric power input (watt hour) during the same period, as determined by test procedures consistent with the U.S. Department of Energy "Test Procedure for Central Air Conditioners, Including Heat Pumps," published in Standard RS-30. When specified in Btu per watt hour, an HSPF of 6.826 is equivalent to a COP of 2.0.

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

HVAC: Heating, ventilating and air-conditioning.

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

HVAC SYSTEM EFFICIENCY: (See **Efficiency, HVAC System.**)

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

IPLV — INTEGRATED PART-LOAD VALUE: A single number figure of merit based on part-load EER or COP expressing part-load efficiency for air conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment as specified in the Air-Conditioning and Refrigeration Institute (ARI) and Cooling Tower Institute (CTI) procedures.

INDIRECTLY CONDITIONED SPACE: An enclosed space within a building that is not a heated or cooled space, whose area weighted heat transfer coefficient to heated or cooled spaces exceeds that to the outdoors or to unconditioned spaces; or through which air from heated or cooled spaces is transferred at a rate exceeding three air changes per hour. Enclosed corridors between conditioned spaces shall be considered as indirectly conditioned space. (See **Heated Space, Cooled Space** and **Unconditioned Space.**)

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

INSULATION BAFFLE: A rigid material, resistant to wind driven moisture, the purpose of which is to allow air to flow freely into the attic or crawl space and to prevent insulation from blocking the ventilation of these spaces, or the loss of insulation. Example materials for this purpose are sheet metal or wax impregnated cardboard.

INSULATION POSITION:

a. **Exterior Insulation Position:** a wall having all or nearly all of its mass exposed to the room air with the insulation on the exterior of the mass.

b. **Integral Insulation Position:** a wall having mass exposed to both room and outside air, with substantially equal amounts of mass on the inside and outside of the insulation layer.

c. **Interior Insulation Position:** a wall not meeting either of the above definitions; particularly a wall having most of its mass external to the insulation layer.

INTERNATIONAL BUILDING CODE (IBC): (See **Washington State Building Code.**)

INTERNATIONAL MECHANICAL CODE (IMC): (See **Washington State Building Code.**)

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.

LINER SYSTEM (LS): A continuous membrane is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the last rated R-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

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.

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

MANUAL: Capable of being operated by personal intervention. (See **Automatic.**)

MECHANICAL SYSTEM: Equipment and components that provide heating, cooling, and ventilation for any purpose other than domestic water systems.

MICROCELL: A wireless communication facility consisting of an antenna that is either: (a) Four (4) feet in height and with an area of not more than 580 square inches; or (b) if a tubular antenna, no more than four (4) inches in diameter and no more than six (6) feet in length; and the associated equipment cabinet that is six (6) feet or less in height and no more than 48 square feet in floor area.

NFPA: National Fire Protection Association.

NFRC: National Fenestration Rating Council.

NET HEAT OUTPUT: The change in the total heat content of the air entering and leaving the equipment (not including supplementary heat and heat from boilers).

NET HEAT REMOVAL: The total difference in heat content of the air entering and leaving the equipment (without heat) or the difference in total heat content of the water or refrigerant entering and leaving the component.

NEW ENERGY: Energy, other than recovered energy, utilized for the purpose of heating or cooling. (See **Energy.**)

NOMINAL R-VALUE: The thermal resistance of insulation alone as determined in accordance with the U.S. Federal Trade Commission R-value rule (CFR Title 16, Part 460) in units of $h \cdot ft^2 \cdot °F/Btu$ at a mean temperature of 75°F. Nominal R-value refers to the thermal resistance of the added insulation in framing cavities or insulated sheathing only and does not include the thermal resistance of other building materials or air films.

NON-RENEWABLE ENERGY SOURCES: All energy sources that are not renewable energy sources including natural gas, oil, coal, wood, liquefied petroleum gas, steam and any utility-supplied electricity.

NONRESIDENTIAL: All spaces as defined in this Code other than Residential.

OCCUPANCY: See the Washington State Building Code.

OCCUPANCY SENSOR: A device that detects occupants within an area, causing any combination of lighting, equipment or appliances to be turned on or shut off.

ON-SITE RENEWABLE ENERGY POWER SYSTEM: Photovoltaic, solar thermal, geothermal, and wind systems used to generate electrical power and located on the building site.

OPAQUE ENVELOPE AREAS: All exposed areas of a building envelope which enclose conditioned space, except openings for doors, glazing and building service systems.

OPEN BLOWN: Loose fill insulation pneumatically installed in an unconfined attic space.

OUTDOOR AIR (OUTSIDE AIR): Air taken from the outdoors and, therefore, not previously circulated through a building.

OVERHEAD GLAZING: A glazing surface that has a slope of less than 60° from the horizontal plane.

PACKAGED TERMINAL AIR-CONDITIONER: A factory-selected combination of heating and cooling components, assemblies or sections intended to serve a room or zone. (For the complete technical definition, see Standard RS-5.)

PERMEANCE (PERM): The ability of a material of specified thickness to transmit moisture in terms of amount of moisture transmitted per unit time for a specified area and differential pressure (grains per hour•ft^2•inches of HG). Permeance may be measured using ASTM E-96-00 or other approved dry cup method as specified in Standard RS-1.

PERSONAL WIRELESS SERVICE FACILITY: A Wireless Communication Facility (WCF), including a microcell, which is a facility for the transmission and/or reception of radio frequency signals and which may include antennas, equipment shelter or cabinet, transmission cables, a support structure to achieve the necessary elevation, and reception and/or transmission devices or antennas.

POOL COVER: A vapor-retardant cover which lies on or at the surface of the pool.

POWER: In connection with machines, the time rate of doing work. In connection with the transmission of energy of all types, the rate at which energy is transmitted; in customary units, it is measured in watts (W) or British thermal units per hour (Btu/h).

PROCESS ENERGY: Energy consumed in support of a manufacturing, industrial, or commercial process other than the maintenance of building comfort or amenities for building occupants.

RADIANT SLAB FLOOR: A slab floor assembly on grade or below, containing heated pipes, ducts, or electric heating cables that constitute a floor or portion thereof for complete or partial heating of the structure.

READILY ACCESSIBLE: See the Washington State Mechanical Code.

RECOOLING: The removal of heat by sensible cooling of the supply air (directly or indirectly) that has been previously heated above the temperature to which the air is to be supplied to the conditioned space for proper control of the temperature of that space.

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

REFRIGERATED WAREHOUSE: A building that contains cold storage spaces or frozen storage spaces that have a total area exceeding 3,000 square feet.

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

RENEWABLE ENERGY SOURCES: Renewable energy sources of energy (excluding minerals) are derived from:

1. Incoming solar radiation, including but not limited to, natural daylighting and photosynthetic processes;
2. Energy sources resulting from wind, waves and tides, lake or pond thermal differences; and
3. Energy derived from the internal heat of the earth, including nocturnal thermal exchanges.

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

RESIDENTIAL: The following two categories comprise all residential spaces for the purposes of this Code:

a. **Single-family:** All spaces within the scope of Section R101.2 of the International Residential Code.

b. **Multifamily:**

i. All Group R Occupancy not falling under the scope of Section 101.2 of the International Residential Code including, but not limited to, dwelling units, hotel/motel guest rooms, dormitories, fraternity/sorority houses, hostels, prisons, and fire stations;

ii. All sleeping areas in Group I Occupancy including, but not limited to, assisted living facilities, nursing homes, patient rooms in hospitals, prisons, and fire stations; and

iii. All sleeping areas in other occupancies including, but not limited to, fire stations.

ROOF: The upper portion of the building envelope, including opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60 degrees from horizontal. For the purposes of determining building envelope requirements, the classifications are defined as follows:

a. **Attic and other roofs:** All other roofs, including roofs with insulation entirely below (inside of) the roof structure (i.e., attics, cathedral ceilings, and single-rafter ceilings), roofs with insulation both above and below the roof structure, and roofs without insulation but excluding metal building roofs.

b. **Metal building roof:** A roof that is:

i. Constructed with a metal, structural, weathering surface;

ii. Has no ventilated cavity; and

iii. Has the insulation entirely below deck (i.e., does not include composite concrete and metal deck construction nor a roof framing system that is separated from the superstructure by a wood substrate) and whose structure consists of one or more of the following configurations:

A. Metal roofing in direct contact with the steel framing members;

B. Insulation between the metal roofing and the steel framing members;

C. Insulated metal roofing panels installed as described in 1 or 2.

ROOF WITH INSULATION ENTIRELY ABOVE DECK: A roof with all insulation installed above (outside of) the roof structure and continuous (i.e., uninterrupted by framing members).

ROOF/CEILING ASSEMBLY: (See **Gross Roof/Ceiling Area.**)

SEER - SEASONAL ENERGY EFFICIENCY RATIO: The total cooling output of an air conditioner during its normal annual usage period, in Btu's, divided by the total electric energy input in watt-hours, during the same period, as determined by 10 CFR, Part 430.

SEMI-HEATED SPACE: Sub-category of **Heated Space.** (See **Heated Space.**)

SEQUENCE: A consecutive series of operations.

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

SERVICE WATER HEATING: Supply of hot water for domestic or commercial purposes other than comfort heating.

SHADED: Glazed area which is externally protected from direct solar radiation by use of devices permanently affixed to the structure or by an adjacent building, topographical feature, or vegetation.

SHADING COEFFICIENT: The ratio of solar heat gain occurring through non-opaque portions of the glazing, with or without integral shading devices, to the solar heat gain occurring through an equivalent area of unshaded, 1/8 inch thick, clear, double-strength glass.

Note: Heat gains to be compared under the same conditions. See Chapter 31 of Standard RS-1, listed in Chapter 7 of this Code.

SHALL: Denotes a mandatory code requirement.

SINGLE FAMILY: (See **Residential.**)

SKYLIGHT: (See **Fenestration.**)

SLAB-BELOW-GRADE: Any portion of a slab floor in contact with the ground which is more than 24 inches below the final elevation of the nearest exterior grade.

SLAB-ON-GRADE, EXTERIOR: Any portion of a slab floor in contact with the ground which is less than or equal to 24 inches below the final elevation of the nearest exterior grade.

SMALL BUSINESS: Any business entity (including a sole proprietorship, corporation, partnership or other legal entity) which is owned and operated independently from all other businesses, which has the purpose of making a profit, and which has fifty or fewer employees, or which has a million dollars or less per year in gross sales, of window products.

SOLAR ENERGY SOURCE: Source of natural daylighting and of thermal, chemical or electrical energy derived directly from conversion of incident solar radiation.

SOLAR HEAT GAIN COEFFICIENT (SHGC): The ratio of the solar heat gain entering the space through the glazing product 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.

SPLIT SYSTEM: Any heat pump or air-conditioning unit which is provided in more than one assembly requiring refrigeration piping installed in the field.

STANDARD FRAMING: All framing practices not defined as "intermediate" or "advanced" shall be considered standard. (See **Advanced Framed Ceiling, Advanced Framed Wall, Intermediate Framed Wall** and Section 1005.2 of this Code.)

SUBSTANTIAL CONTACT: A condition where adjacent building materials are placed in a manner that proximal surfaces are contiguous, being installed and supported as to eliminate voids between materials, without compressing or degrading the thermal performance of either product.

SYSTEM: A combination of central or terminal equipment or components and/or controls, accessories, interconnecting means and terminal devices by which

energy is transformed so as to perform a specific function, such as HVAC, service water heating or illumination.

TAPERING: Installation of a reduced level of ceiling insulation at the eaves, due to reduced clearance.

THERMAL BY-PASS: An area where the envelope surrounding the conditioned space is breached, or where an ineffective application compromises the performance of a thermal or infiltration barrier, increasing the structure's energy consumption by exposing finished surfaces to ambient conditions and additional heat transfer.

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

THERMAL RESISTANCE (R): The reciprocal of thermal conductance ($h \cdot ft^2 \cdot °F/Btu$).

THERMAL TRANSMITTANCE (U): The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films ($Btu/h \cdot ft^2 \cdot °F$).

THERMAL TRANSMITTANCE, OVERALL (U_O): The overall (average) heat transmission of a gross area of the exterior building envelope ($Btu/h \cdot ft^2 \cdot °F$). The U_O-factor applies to the combined effect of the time rate of heat flows through the various parallel paths, such as glazing, doors and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/ceiling.

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

TOTAL ON-SITE ENERGY INPUT: The combination of all the energy inputs to all elements and accessories as included in the equipment components, including but not limited to, compressor(s), compressor sump heater(s), circulating pump(s), purge device(s), fan(s) and the HVAC system component control circuit.

TRANSMISSION COEFFICIENT: The ratio of the solar heat gain through a glazing system to that of an unshaded single pane of double strength window glass under the same set of conditions.

TRANSVERSE JOINT: The primary connection between two air distribution system fittings.

U-FACTOR: (See **Thermal Transmittance**.)

U-VALUE: (See **U-factor**.)

UNITARY COOLING AND HEATING EQUIPMENT: One or more factory-made assemblies which include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well. Where such equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

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

VAPOR RETARDER: A layer of low moisture transmissivity material (not more than 1.0 perm dry cup) placed over the warm side (in winter) of insulation, over the exterior of below grade walls, and under floors as ground cover to limit the transport of water and water vapor through exterior walls, ceilings and floors. Vapor retarding paint, listed for this application, also meets this definition.

VAULTED CEILINGS: All ceilings where enclosed joist or rafter space is formed by ceilings applied directly to the underside of roof joists or rafters.

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

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

VERTICAL GLAZING: A glazing surface that has a slope of 60° or greater from the horizontal plane.

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

a. **Above-grade wall:** A wall that is not a below-grade wall.

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

c. **Mass wall:** A wall with a heat capacity exceeding 7 $Btu/ft^2°F$ or 5 $Btu/ft^2°F$, provided that the wall has a material unit weight not greater than 120 lb/ft^3.

d. **Metal building wall:** A wall whose structure consists of metal spanning members supported by steel structural members (i.e., does not include spandrel glass or metal panels in curtain wall systems).

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

f. **Wood-framed and other walls:** All other wall types, including wood stud walls.

WALLS (EXTERIOR): Any member or group of members which defines the exterior boundaries or courts of a building and which have a slope of 60° or greater from the horizontal plane, and separates conditioned from unconditioned space. Band joists between floors are to be considered a part of exterior walls.

WASHINGTON STATE BUILDING CODE: The Washington State Building Code is comprised of the International Building Code; the International Residential Code, the International Mechanical Code; the International Fire Code; the Uniform Plumbing Code; the state regulations for barrier-free facilities, as designated in RCW 19.27.031; the state energy code; and any other codes so designated by the Washington state legislature as adopted and amended by the State Building Code Council.

ZONE: A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device. Each dwelling unit in residential buildings shall be considered a single zone.

CHAPTER 3
DESIGN CONDITIONS

SECTION 301 — DESIGN CRITERIA

301.1 General: The criteria of this chapter establish the design conditions upon which the minimum thermal design requirements of the building envelope and the design of the HVAC system are to be based.

301.2 Heating and Cooling: A building that is designed to be both heated and cooled shall meet the more stringent of the heating or cooling requirements as required in this Code when requirements of the exterior envelope differ.

SECTION 302 — THERMAL DESIGN PARAMETERS

302.1 Exterior Design Conditions: The heating or cooling outdoor design temperatures shall be selected from Table 3-1.

302.2 Interior Design Conditions

302.2.1 Indoor Design Temperature: Indoor design temperature shall be 70°F for heating and 78°F for cooling.

EXCEPTION: Other design temperatures may be used for equipment selection if it results in a lower energy usage.

302.2.2 Humidification: If humidification is provided during heating, it shall be designed for a maximum relative humidity of 30%. When comfort air conditioning is provided, the actual design relative humidity within the comfort envelope as defined in Standard RS-4, listed in Chapter 7, shall be selected for minimum total HVAC system energy use.

302.3 Climate Zones: All buildings shall comply with the requirements of the appropriate climate zone as defined herein.

ZONE 1: Climate Zone 1 shall include all counties not included in Climate Zone 2.

ZONE 2: Climate Zone 2 shall include: Adams, Chelan, Douglas, Ferry, Grant, Kittitas, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens and Whitman counties.

SECTION 303 — MECHANICAL VENTILATION

The minimum requirements for ventilation shall comply with Section M1508 of the Washington State Residential Code (WAC 51-51).

TABLE 3-1
OUTDOOR DESIGN TEMPERATURES

Location	Outdoor Design Temp Heating (°F)	Outdoor Design Temp Cooling (°F)	Location	Outdoor Design Temp Heating (°F)	Outdoor Design Temp Cooling (°F)	Location	Outdoor Design Temp Heating (°F)	Outdoor Design Temp Cooling (°F)
Aberdeen 20NNE	25	83	Connell 4NNW	6	100	John Day Dam	19	100
Anacortes	24	72	Cougar 5E	25	93	Kent	21	85
Anatone	-4	89	Dallesport AP	14	99	Kirkland	17	83
Auburn	25	84	Darrington RS	13	85	La Grande	23	88
Battleground	19	91	Davenport	5	92	Leavenworth	-3	93
Bellevue	24	83	Edmonds	24	82	Little Goose Dam	22	101
Bellingham 2N	19	78	Ellensburg AP	2	90	Long Beach 3NNE	25	77
Blain	17	73	Elma	24	88	Longview	24	87
Bremerton	29	83	Ephrata AP	7	97	Lower Granite Dam	14	98
Burlington	19	77	Everett Paine AFB	21	79	Lower Monument Dam	18	103
Chehalis	21	87	Forks 1E	23	81	Marysville	23	79
Chelan	10	89	Glacier RS	13	82	Metaline Falls	-1	89
Cheney	4	94	Glenoma (Kosmos)	18	89	Methow 2W	1	89
Chesaw	-11	81	Goldendale	7	94	Nespelem 2S	-4	93
Clarkston	10	94	Grays River Hatchery	24	86	Newhalem	19	89
Cle Elum	1	91	Greenwater	1.4	84	Newport	-5	92
Colfax 1NW	2	94	Grotto	21	84	Northport	2	92
Colville AP	-2	92	Hoquiam AP	26	79	Oak Harbor	16	74
Concrete	19	83	Inchelium 2NW	0	92	Odessa	7	100

TABLE 3-1
OUTDOOR DESIGN TEMPERATURES (Continued)

Location	Outdoor Design Temp Heating (°F)	Outdoor Design Temp Cooling (°F)	Location	Outdoor Design Temp Heating (°F)	Outdoor Design Temp Cooling (°F)	Location	Outdoor Design Temp Heating (°F)	Outdoor Design Temp Cooling (°F)
Olga 2SE	24	71	Raymond	28	81	Stevens Pass	6	77
Olympia AP	17	85	Redmond	17	83	Tacoma CO	29	82
Omak 2NW	3	90	Republic	-9	87	Tatoosh Island	31	63
Oroville	5	93	Richland	11	101	Toledo AP	17	84
Othello	9	98	Ritzville	6	99	Vancouver	22	88
Packwood	16	90	Satus Pass	10	90	Vashon Island	28	78
Plain	-3	89	Seattle: SeaTac AP	24	83	Walla Walla AP	6	96
Pleasant View	16	98	Sedro Woolley 1E	19	78	Waterville	1	88
Pomeroy	3	95	Sequim	23	78	Wellpinit	1	93
Port Angeles	28	75	Shelton	23	85	Wenatchee CO	10	92
Port Townsend	25	76	Smyrna	8	102	Whidbey Island	11	71
Prosser	12	97	Snohomish	21	81	Willapa Harbor	26	81
Puyallup	19	86	Snoqualmie Pass	6	80	Wilson Creek	3	96
Quilcene 2SW	23	83	Spokane AP	4	92	Winthrop 1WSW	-12	91
Quinault RS	25	84	Spokane CO	10	96	Yakima AP	11	94
Rainier, Longmire	15	85	Stampede Pass	7	76			
Paradise RS	8	71	Stehekin 3 NW	12	85			

ABBREVIATIONS: AFB Air Force Base AP Airport CO City Office RS Ranger Station
Typical: "4(miles)NE"

CHAPTER 4
BUILDING DESIGN BY SYSTEMS ANALYSIS

SECTION 401 — SCOPE

401.1 General: This chapter establishes design criteria in terms of total energy use by a building, including all of its systems. Analysis of design for all single-family residential shall comply with Sections 402.1 through 402.6. In addition, the design shall comply with the additional energy efficiency requirements of Chapter 9.

SECTION 402 — SYSTEMS ANALYSIS

402.1 Special Requirements for Single-Family Residential:

402.1.1 Energy Budgets: Proposed buildings designed in accordance with this section shall be designed to use no more energy from non-renewable sources for space heating, space cooling and domestic hot water heating than a standard building whose enclosure elements and energy consuming systems are designed in accordance with Section 502.2 of this Code for the appropriate climate zone and heating system type and cooling system type and whose mechanical system type is the same as the proposed building and which complies with Section 503 of this Code. Energy derived from renewable sources may be excluded from the total annual energy consumption attributed to the alternative building.

402.1.2 Calculation of Energy Consumption: The application for a building permit shall include documentation which demonstrates, using a calculation procedure as listed in Chapter 8, or an approved alternate, that the proposed building's annual space heating , space cooling and domestic hot water heating energy use does not exceed the annual space heating, space cooling and domestic hot water heating energy use of a standard building conforming to Chapter 5 of this Code for the appropriate climate zone. The total calculated annual energy consumption shall be shown in units of kWh/ft^2-year or Btu/ft^2-year of conditioned area.

402.1.3 Input Values: The following standardized input values shall be used in calculating annual space heating budgets:

Parameter	Value
Thermostat	
Thermostat set point, heating	65°F
Thermostat set point, cooling	78°F
Thermostat night set back	65°F
Thermostat night set back period	0 hours
Internal Gain	3000 Btu/h
Domestic Hot Water Heater Setpoint	120°F
Domestic Hot Water Consumption	20 gallons per person per day
Minimum Heat Storage	Calculated using standard engineering practice for the actual building or as approved.
Site Weather Data	Typical meteorological year (TMY) or ersatz TMY data for the closest appropriate TMY site or other sites as approved.
Heating and Cooling Equipment Efficiency	Equipment shall comply with Section 1411

The standard building shall be modeled with glazing area distributed equally among the four cardinal directions. Parameter values that may be varied by the building designer to model energy saving options include, but are not limited to, the following:

1. Overall thermal transmittance, U_O, of building envelope or individual building components.
2. Heat storage capacity of building.
3. Glazing orientation; area; and solar heat gain coefficients (where Chapter 5 does not contain SHGC requirements, the standard design shall be modeled with glazing SHGC as determined by Tables 13-1 and 13-2. SHGC values shall be determined in accordance with Section 1312.2.).
4. Heating system efficiency.

Parameters values that may not be varied:

- Domestic hot water consumption

402.1.4 Solar Shading and Access: Building designs using passive solar features with 8% or more south facing equivalent glazing to qualify shall provide to the building official a sun chart or other approved documentation depicting actual site shading for use in calculating compliance under this section. The building shall contain at least 45 Btu/°F for each square foot of south facing glass.

402.1.5 Infiltration: Infiltration levels used shall be set at 0.35 air changes per hour for thermal calculation purposes only.

402.1.6 Heat Pumps: The heating season performance factor (HSPF) for heat pumps shall be calculated using procedures consistent with Section 5.2 of the U.S. Department of Energy "Test Procedure for Central Air Conditioners, Including Heat Pumps," published in the December 27, 1979, Federal Register, Vol. 44, No. 24, 10 CFR 430. Climate data as specified above, the

proposed buildings overall thermal performance value (Btu/°F) and the standardized input assumptions specified above shall be used to model the heat pump's HSPF.

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

> **EXCEPTION:** Chapters 5 and 6 of this Code establish criteria for different energy-consuming and enclosure elements of the building which will eliminate the requirement for an annual systems energy analysis while meeting the intent of this Code.

A building designed in accordance with this chapter will be deemed as complying with this Code if the calculated annual energy consumption is 16 percent less than a similar building (defined as a "standard design") whose enclosure elements and energy-consuming systems are designed in accordance with Chapter 5.

For an alternate 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.

402.3 Design: The standard design, conforming to the criteria of Chapter 5 and the proposed alternative design shall be designed on a common basis as specified herein.

The comparison shall be expressed as kBtu or kWh input per square foot of conditioned floor area per year at the building site.

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

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 402.5.

b. 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.

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

a. Design requirements--Environmental requirements as required in Chapter 3.

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, moisture and heat transfer characteristics.

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

e. Mechanical equipment--Design capacity, part load profile.

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

> **EXCEPTION:** Single-family residential shall comply with the calculation procedures in Chapter 8, or an approved alternate.

402.6 Documentation: Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis comparison report. The report shall provide technical detail on the two building and system designs and on the data used in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of Chapter 4 of this Code.

CHAPTER 5
BUILDING DESIGN
BY COMPONENT PERFORMANCE APPROACH

SECTION 501 — SCOPE

501.1 General: Buildings that are heated or mechanically cooled shall be constructed so as to provide the required thermal performance of the various components. A building that is designed to be both heated and cooled shall meet the more stringent of the heating or cooling requirements as provided in this Code when requirements of the exterior envelope differ. In addition, the design shall comply with the additional energy efficiency requirements of Chapter 9.

SECTION 502 — BUILDING ENVELOPE REQUIREMENTS

502.1 General

502.1.1: The stated U- or F-factor of any component assembly, listed in Table 5-1, such as roof/ceiling, opaque wall or opaque floor may be increased and the U-factor for other components decreased, provided that the total heat gain or loss for the entire building envelope does not exceed the total resulting from compliance to the U-factors specified in this section.

The U-factors for typical construction assemblies are included in Chapter 10. These values shall be used for all calculations. Where proposed construction assemblies are not represented in Chapter 10, values shall be calculated in accordance with Chapters 16 through 18 and 25 through 27 in Standard RS-1 listed in Chapter 7, using the framing factors listed in Chapter 10 where applicable.

For envelope assemblies containing metal framing, the U-factor shall be determined by one of the following methods:

1. Results of laboratory or field measurements.
2. Standard RS-1, listed in Chapter 7, where the metal framing is bonded on one or both sides to a metal skin or covering.
3. The zone method as provided in Chapter 25 of Standard RS-1, listed in Chapter 7.
4. Results of parallel path correction factors for effective framing/cavity R-values as provided in Table 10-5A: Effective R-Values for Metal Framing and Cavity Only for metal stud walls and roof/ceilings.

502.1.2: For consideration of thermal mass effects, see Section 402.4.

502.1.3: When return air ceiling plenums are employed, the roof/ceiling assembly shall:

a. For thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly; and
b. For gross area purposes, be based upon the interior face of the upper plenum surface.

502.1.4 Insulation

502.1.4.1 General: All insulating materials shall comply with Sections 2603 and/or 719 of the International Building Code. Substantial contact of the insulation with the surface being insulated is required. All insulation materials shall be installed according to the manufacturer's instructions to achieve proper densities and maintain uniform R-values and shall be installed in a manner which will permit inspection of the manufacturer's R-value identification mark. To the maximum extent possible, insulation shall extend over the full component area to the intended R-value.

The thickness of roof/ceiling insulation that is either blown in or spray-applied shall be identified by inches of thickness, density and R-value markers installed at least one for every 300 square feet (28 m^2) through the attic and/or ceiling space. In attics, the markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers a minimum 1.0 inch (25 mm) in height. Each marker shall face the attic access. The thickness of installed attic insulation shall meet or exceed the minimum initial installed thickness shown by the marker. ⇦

502.1.4.2 Insulation Materials: All insulation materials including facings such as vapor barriers or breather papers installed within floor/ceiling assemblies, roof/ceiling assemblies, walls, crawl spaces, or attics shall have a flame spread rating of less than 25 and a smoke density not to exceed 450 when tested in accordance with ASTM E84-01.

EXCEPTIONS: 1. Foam plastic insulation shall comply with Section 2603 of the International Building Code.

2. When such materials are installed in concealed spaces of Types III, IV and V construction, the flame spread and smoke developed limitations do not apply to facing, provided that the facing is installed in substantial contact with the unexposed surface of the ceiling, floor or wall finish.

3. Cellulose insulation shall comply with Section 719 of the International Building Code.

502.1.4.3 Clearances: Where required, insulation shall be installed with clearances according to manufacturer's specifications. Insulation shall be installed so that required ventilation is unobstructed. For blown or poured loose fill insulation, clearances shall be maintained through installation of a permanent retainer.

502.1.4.4 Access Hatches and Doors: Access doors from conditioned spaces to unconditioned spaces (e.g., attics and crawl spaces) shall be weatherstripped and insulated to a level equivalent to the insulation on the surrounding surfaces. Access shall be provided to all equipment which prevents damaging or compressing the insulation. A wood framed or equivalent baffle or retainer must be provided when loose fill insulation is installed, the purpose of which is to prevent the loose fill insulation from spilling into the

living space when the attic access is opened, and to provide a permanent means of maintaining the installed R-value of the loose fill insulation.

502.1.4.5 Roof/Ceiling Insulation: Where two or more layers of rigid board insulation are used in a roof assembly, the vertical joints between each layer shall be staggered. Open-blown or poured loose fill insulation may be used in attic spaces where the slope of the ceiling is not more than 3 feet in 12 and there is at least 30 inches of clear distance from the top of the bottom chord of the truss or ceiling joist to the underside of the sheathing at the roof ridge. When eave vents are installed, baffling of the vent openings shall be provided so as to deflect the incoming air above the surface of the insulation. Baffles shall be rigid material, resistant to wind driven moisture. Requirements for baffles for ceiling insulation shall meet the International Building Code Section 1203.2 for minimum ventilation requirements. When feasible, the baffles shall be installed from the top of the outside of the exterior wall, extending inward, to a point 6 inches vertically above the height of noncompressed insulation, and 12 inches vertically above loose fill insulation.

502.1.4.6 Wall Insulation: Insulation installed in exterior walls shall comply with the provisions of this section. All wall insulation shall fill the entire framed cavity. Exterior wall cavities isolated during framing shall be fully insulated to the levels of the surrounding walls. All faced insulation shall be face stapled to avoid compression.

EXCEPTION: Framed cavity can be empty or partially filled provided:

1. The wall assembly calculations are performed along with a completed performance calculation for the whole building; and
2. Insulation installed in partially filled cavities is not included in the performance calculation.

502.1.4.7 Floor Insulation: Floor insulation shall be installed in a permanent manner in substantial contact with the surface being insulated. Insulation supports shall be installed so spacing is no more than 24 inches on center. Foundation vents shall be placed so that the top of the vent is below the lower surface of the floor insulation.

EXCEPTIONS: 1. Insulation may be omitted from floor areas over heated basements, heated garages or underfloor areas used as HVAC supply plenums. When foundation walls are insulated, the insulation shall be attached in a permanent manner. The insulation shall not block the airflow through foundation vents when installed. When foundation vents are not placed so that the top of the vent is below the lower surface of the floor insulation, a permanently attached baffle shall be installed at an angle of 30° from horizontal, to divert air flow below the lower surface of the floor insulation.

2. Substantial contact with the surface being insulated is not required in enclosed floor/ceiling assemblies containing ducts where full depth insulation is installed between the duct and the exterior surface.

502.1.4.8 Slab-On-Grade: Slab-on-grade insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance of 24 inches or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance of 24 inches. Above grade insulation shall be protected. A two-inch by 2-inch (maximum) nailer may be placed at the finished floor elevation for attachment of interior finish materials.

502.1.4.9 Radiant Slabs: The entire area of a radiant slab shall be thermally isolated from the soil with a minimum of R-10 insulation. The insulation shall be an approved product for its intended use. If a soil gas control system is present below the radiant slab, which results in increased convective flow below the radiant slab, the radiant slab shall be thermally isolated from the sub-slab gravel layer. R-10 radiant slab insulation is required for all compliance paths.

502.1.4.10 Below-Grade Walls: Below-grade exterior wall insulation used on the exterior (cold) side of the wall shall extend from the top of the below-grade wall to the top of the footing and shall be approved for below-grade use. Above-grade insulation shall be protected.

Insulation used on the interior (warm) side of the wall shall extend from the top of the below-grade wall to the below-grade floor level.

502.1.5 Glazing and Door U-Factors: Glazing and door U-factors shall be determined in accordance with Sections 502.1.5.1 and 502.1.5.2. All products shall be labeled with the NFRC certified or default U-factor. The labeled U-factor shall be used in all calculations to determine compliance with this Code. Sealed insulating glass shall conform to, or be in test for, ASTM E-774-81 class A. ⇦

502.1.5.1 Standard Procedure for Determination of Glazing U-Factors: U-factors for glazing shall be determined, certified and labeled in accordance with the National Fenestration Rating Council (NFRC) Product Certification Program (PCP), as authorized by an independent certification and inspection agency licensed by the NFRC. Compliance shall be based on the Residential Model Size. Product samples used for U-factor determinations shall be production line units or representative of units as purchased by the consumer or contractor. Products that are listed in the NFRC Certified Products Directory or certified to the NFRC Standard shall not use default values.

EXCEPTIONS: 1. Glazing products without NFRC ratings may be assigned default U-factors from Table 10-6A for vertical glazing and from Table 10-6E for overhead glazing.

2. Units without NFRC ratings produced by a small business may be assigned default U-factors from Table 10-6A for garden windows, from Table 10-6B for other vertical glazing, and from Table 10-6E for overhead glazing.

502.1.5.2 Standard Procedure for Determination of Door U-Factors: All doors, including fire doors, shall be assigned default U-factors from Table 10-6C.

EXCEPTIONS: 1. U-factors determined, certified and labeled in accordance with the National Fenestration Rating Council (NFRC) Product Certification Program (PCP), as authorized by an independent certification and inspection agency licensed by the NFRC.

2. The default values for the opaque portions of doors shall be those listed in Table 10-6C, provided that the U-factor listed for a door with a thermal break shall only be allowed if both the door and the frame have a thermal break.

3. One unlabeled or untested exterior swinging door with the maximum area of 24 square feet may be installed for ornamental, security or architectural purposes. Products using this exception shall not be included in the U-factor calculation requirements; however, glazing area shall be included in glazing area calculations.

502.1.6 Moisture Control

502.1.6.1 Vapor Retarders: Vapor retarders shall be installed on the warm side (in winter) of insulation as specified in the following cases.

EXCEPTION: Vapor retarder installed with not more than 1/3 of the nominal R-value between it and the conditioned space.

502.1.6.2 Floors: Floors separating conditioned space from unconditioned space shall have a vapor retarder installed. The vapor retarder shall have a one perm dry cup rating or less (i.e. four mil [0.004 inch thick] polyethylene or kraft faced material).

502.1.6.3 Roof/Ceilings: Roof/ceiling assemblies where the ventilation space above the insulation is less than an average of 12 inches shall be provided with a vapor retarder. Faced batt insulation where used as a vapor retarder shall be face stapled. Single rafter joist vaulted ceiling cavities shall be of sufficient depth to allow a minimum one inch vented air space above the insulation.

EXCEPTION: Unvented attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) shall be permitted if all of the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope.

2. No interior vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly.

3. Where wood shingles or shakes are used, a minimum ¼ inch (6 mm) vented air space separates the shingles or shakes and the roofing underlayment above the structural sheathing.

4. Any air-impermeable insulation shall be a vapor retarder, or shall have a vapor retarder coating or covering in direct contact with the underside of the insulation.

5. Either items a, b or c shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.

a. Air-impermeable insulation only. Insulation shall be applied in direct contact to the underside of the structural roof sheathing.

b. Air-permeable insulation only. In addition to the air-permeable insulation installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing as specified per WA Climate Zone for condensation control:

i. Climate Zone 1: R-10 minimum rigid board or air-impermeable insulation R-value.

ii. Climate Zone 2: R-25 minimum rigid board or air-impermeable insulation R-value.

c. Air-impermeable and air-permeable insulation. The air-impermeable insulation shall be applied in direct contact to the underside of the structural roof sheathing as specified per WA Climate Zone for condensation control. The air-permeable insulation shall be installed directly under the air impermeable insulation.

i. Climate Zone 1: R-10 minimum rigid board or air-impermeable insulation R-value.

ii. Climate Zone 2: R-25 minimum rigid board or air-impermeable insulation R-value.

502.1.6.4: Vapor retarders shall not be required in roof/ceiling assemblies where the ventilation space above the insulation averages 12 inches or greater.

502.1.6.5: Vapor retarders shall not be required where all of the insulation is installed between the roof membrane and the structural roof deck.

502.1.6.6 Walls: Walls separating conditioned space from unconditioned space shall have a vapor retarder installed. Faced batt insulation shall be face stapled.

EXCEPTION: For Climate Zone 1, wood framed walls with a minimum of nominal R-5 continuous insulated sheathing installed outside of the framing and structural sheathing. For Climate Zone 2, wood framed walls with a minimum of nominal R-7.5 continuous insulated sheathing installed outside of the framing and structural sheathing. The interior cavity insulation for this exception shall be a maximum of nominal R-21.

502.1.6.7 Ground Cover: A ground cover of six mil (0.006 inch thick) black polyethylene or approved equal shall be laid over the ground within crawl spaces. The ground cover shall be overlapped 12 inches minimum at the joints and shall extend to the foundation wall.

EXCEPTION: The ground cover may be omitted in crawl spaces if the crawl space has a concrete slab floor with a minimum thickness of 3-1/2 inches.

502.2 Thermal Criteria for Single-Family Residential

502.2.1 UA Calculations: The proposed UA as calculated using Equations 2 and 3 shall not exceed the target UA as calculated using Equation 1. For the purpose of determining equivalent thermal performance, the glazing area for the target UA shall be calculated using values in Table 5-1. The opaque door area shall be the same in the target UA and the proposed UA. When showing compliance with Table 9-1 using options 3a, 3b, or 3c, the proposed design shall be less than the target UA by the fraction noted in the table.

EXCEPTION: Log and solid timber walls that have a minimum average thickness of 3.5" and with space heat type other than electric resistance, are exempt from wall target UA and proposed UA calculations.

502.2.2 Space Heat Type: The following two categories comprise all space heating types:

1. **Electric Resistance:** Space heating systems which include baseboard units, radiant units and forced air units as either the primary or secondary heating system.

   EXCEPTION: Electric resistance systems for which the total electric heat capacity in each individual dwelling unit does not exceed the greater of:

   1. One thousand watts (1000 W) per dwelling unit, or;
   2. One watt per square foot (1 W/ft^2) of the gross floor area.

2. **Other:** All gas, wood, oil and propane space heating systems, unless electric resistance is used as a secondary heating system, and all heat pump space heating systems. (See EXCEPTION, Electric Resistance, Section 502.2.2 above.)

502.3 Reserved.

502.4 Air Leakage

502.4.1 General: The requirements of this section shall apply to all buildings and structures, or portions thereof, and only to those locations separating outdoor ambient conditions from interior spaces that are heated or mechanically cooled.

502.4.2 Doors and Windows, General: Exterior doors and windows shall be designed to limit air leakage into or from the building envelope. Site-constructed doors and windows shall be sealed in accordance with Section 502.4.3.

502.4.3 Seals and Weatherstripping:

a. Exterior joints around windows and door frames, openings between walls and foundation, between walls and roof and wall panels; openings at penetrations of utility services through walls, floors and roofs; and all other openings in the building envelope and all other openings in between units shall be sealed, caulked, gasketed or weatherstripped to limit air leakage. Other exterior joints and seams shall be similarly treated, or taped, or covered with moisture vapor permeable housewrap.

b. All exterior doors or doors serving as access to an enclosed unheated area shall be weatherstripped to limit leakage around their perimeter when in a closed position.

c. Site built windows are exempt from testing but shall be made tight fitting. Fixed lites shall have glass retained by stops with sealant or caulking all around. Operating sash shall have weatherstripping working against overlapping trim and a closer/latch which will hold the sash closed. The window frame to framing crack shall be made tight with caulking, overlapping membrane or other approved technique.

d. Openings that are required to be fire resistive are exempt from this section.

502.4.4 Recessed Luminaires: When installed in contact with the building envelope, recessed luminaires shall be Type IC rated and certified under ASTM E283 to have no more than 2.0 cfm air movement from the conditioned space to the ceiling cavity. The luminaires shall be tested at 75 Pascals or 1.57 lbs/ft^2 pressure difference and have a label attached, showing compliance with this test method. Recessed lighting fixtures shall be installed with a gasket or caulk between the fixture and ceiling to prevent air leakage.

502.4.5 Building Air Leakage Testing: Building envelope air leakage control shall be considered acceptable when tested to have an air leakage less than 0.00030 Specific Leakage Area (SLA) when tested with a blower door at a press of 50 Pascals (0.2 inch w.g.). Testing shall occur at any time after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation, and combustion appliances and sealing thereof. When required by the building official, the test shall be conducted in the presence of department staff. The blower door test results shall be recorded on the certificate required in Section 105.4.

EXCEPTIONS: 1. Additions less than 750 square feet.

2. Once visual inspection has confirmed the presence of a gasket (see Section 502.4), operable windows and doors manufactured by small business shall be permitted to be sealed off at the frame prior to the test.

Specific Leakage Area (SLA) shall be calculated as follows:

$$SLA = (CFM50 \times 0.055)/(CFA \times 144)$$

Where:

CFM50 = Blower door fan flow at 50 Pascal pressure difference

CFA = Conditioned Floor Area of the housing unit

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed.
2. Dampers shall be closed, but not sealed; including exhaust, intake, makeup air, back draft, and flue dampers;
3. Interior doors connecting conditioned spaces shall be open; access hatches to conditioned crawl spaces and conditioned attics shall be open; doors connecting to unconditioned spaces shall be closed but not sealed;
4. Exterior openings for continuous operation ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling system(s) shall be turned off;
6. HVAC ducts supply and return registers shall not be sealed.

SECTION 503 —MECHANICAL SYSTEMS

503.1 General: This section covers the determination of design requirements, system and component performance, control requirements, insulating systems and duct sealing. For all other duct construction requirements, refer to the State Mechanical Code (WAC 51-52).

503.2 Calculations of Heating/Cooling Loads and System Sizing Limits: The design parameters specified in Chapter 3 shall apply for all computations.

503.2.1 Calculation Procedures: Heating and cooling design loads for the purpose of sizing HVAC systems are required and shall be calculated in accordance with accepted engineering practice, including infiltration and ventilation.

503.2.2 Space Heating and Space Cooling System Sizing Limits: Mechanical systems for all buildings which provide space heating and/or space cooling shall be sized as required in IRC Section M1401.3.

EXCEPTIONS: The following limited exemptions from the sizing limit shall be allowed; however, in all cases heating and/or cooling design load calculations shall be submitted.

1. For equipment which provides both heating and cooling in one package unit, including heat pumps with electric heating and cooling and gas-pack units with gas heating and electric cooling, compliance need only be demonstrated for the larger of the space heating or space cooling load for the selected system size.
2. Natural gas- or oil-fired space heating equipment whose total rated space heating output in any one dwelling unit is 40,000 Btu/h or less is exempt from the sizing limit.
3. Stand-by equipment may be installed if controls and other devices are provided which allow redundant equipment to operate only when the primary equipment is not operating.
4. Electric resistance heaters under 2 kW.

503.3 Simultaneous Heating and Cooling: Systems and equipment that provide simultaneous heating and cooling shall comply with the requirements in, as appropriate, Section 1422 or Section 1435.

503.4 HVAC Equipment Performance Requirements: All heating equipment shall meet the requirements of the National Appliance Energy Conservation Act (NAECA) and be so labeled. Equipment shall also comply with Section 1411.

503.5 Reserved.

503.6 Balancing: The HVAC system design shall provide a means for balancing air and water systems. Balancing the system shall include, but not be limited to, dampers, temperature and pressure test connections and balancing valves.

503.7 Cooling with Outdoor Air (Economizer Cycle): Systems and equipment that provide mechanical cooling shall comply with Section 1413 and, as appropriate, Section 1423 or 1433.

503.8 Controls

503.8.1 Temperature Control: The primary space conditioning system within each dwelling unit shall be provided with at least one programmable thermostat for the regulation of temperature. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/ weekends) and be capable of providing at least two programmable setback periods per day.

Each additional system provided within a dwelling unit shall be provided with at least one adjustable thermostat for the regulation of temperature. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends).

EXCEPTIONS: 1. Systems controlled by an occupant sensor that is capable of shutting the system off when no occupant is sensed for a period of up to 30 minutes.

2. Systems controlled solely by a manually operated timer capable of operating the system for no more than two hours.

Each thermostat shall be capable of being set by adjustment or selection of sensors as follows:

503.8.1.1: When used to control heating only: 55°F to 75°F.

503.8.1.2: When used to control cooling only: 70°F to 85°F.

503.8.1.3: When used to control both heating and cooling, it shall be capable of being set from 55°F to 85°F and shall be capable of operating the system heating and cooling in sequence. The thermostat and/or control system shall have an adjustable deadband of not less than 10°F.

503.8.2 Humidity Control: If a system is equipped with a means for adding moisture to maintain specific selected relative humidities in space or zones, a humidistat shall be provided. Humidistats shall be capable of being set to prevent new energy from being used to produce space-relative humidity above 30%.

EXCEPTION: Special uses requiring different relative humidities may be permitted when approved by the building official.

503.8.3 Zoning for Temperature Control

503.8.3.1 One- and Two-Family Dwellings: At least one thermostat for regulation of space temperature shall be provided for each separate system. In addition, a readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each zone or floor.

503.8.3.2 Multifamily Dwellings: For multifamily dwellings, each individual dwelling unit shall have at least one thermostat for regulation of space temperature. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each room.

503.8.3.3 Control Setback and Shut-Off: One- and Two-Family and individual Multifamily Dwelling units--The thermostat required in Section 503.8.3.1 or Section 503.8.3.2, or an alternate means such as a switch or clock, shall provide a readily accessible, manual or automatic means for reducing the energy required for heating and cooling during the periods of non-use or reduced need, such as, but not limited to, unoccupied periods and sleeping hours. Lowering thermostat set points to reduce energy consumption of heating systems shall not cause energy to be expended to reach the reduced setting.

503.8.3.4 Systems Serving Multiple Dwelling Units, Guest Rooms, and Common Areas: Systems that serve more than two dwelling units, guest rooms, and common areas shall comply with the control requirements in Sections 1412 and 1432, with the exceptions of Sections 1412.4.2 and 1432.1.

503.8.3.5 Heat Pump Controls: Heat pumps with supplementary electric resistance heaters shall have controls complying with Section 503.8.1. In addition, controls shall meet the following requirements:

1. Prevent supplementary heater operation when the heating load can be met by the heat pump alone; and

2. The cut-on temperature for compression heating shall be higher than the cut-on temperature for supplementary heating, and the cut-off temperature for compressing heating shall be higher than the cut-off temperature for supplementary heating.

All heat pumps installed under this section shall include the capability to lock out the supplementary heat based on outdoor temperature. This control shall have a maximum setting of 40°F. At final inspection, the lock out control shall be set to 32°F or less.

EXCEPTION: The controls may allow supplementary heater operation during defrost.

503.9 Air Handling Duct System Insulation: Ducts, plenums and enclosures installed in or on buildings shall be thermally insulated per Table 5-11.

EXCEPTIONS: Duct insulation (except where required to prevent condensation) is not required in any of the following cases:

1. When the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building.

2. Within the HVAC equipment.

3. Exhaust air ducts.

4. Supply or return air ducts installed in basements or cellars in one- and two-family dwellings.

5. The insulation required on supply air ducts may be reduced to R-4 when installed in buffer spaces not intended for human occupancy such as insulated crawl spaces and enclosed attic spaces. The buffer space must be air sealed and insulation to the full value of conditioned spaces.

503.10 Ducts

503.10.1 Installation of ducts in exterior walls, floors or ceilings shall not displace required envelope insulation. Building cavities may not be used as ducts.

503.10.2 Leakage Testing: Ducts shall be leak tested in accordance with RS-33, using the maximum duct leakage rates specified in Section 503.10.3.

503.10.3 Sealing: All ducts, air handlers, filter boxes, and building cavities used as ducts shall be sealed. Joints and seams shall comply with Section M1601.3 of the International Residential Code or Section 603.9 of the International Mechanical Code. Duct tightness testing shall be conducted to verify that the ducts are sealed. A signed affidavit documenting the test results shall be provided to the jurisdiction having authority by the testing agent. When required by the building official, the test shall be conducted in the presence of department staff. Duct tightness shall be verified by either of the following:

1. Post-construction test: Leakage to outdoors shall be less than or equal to 6 cfm per 100 square feet of conditioned floor area or a total leakage less than or equal to 8 cfm per 100 square feet of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pascals) across the entire system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test.

2. Rough-in test: Total leakage shall be less than or equal to 6 cfm per 100 square feet of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pascals) across the roughed-in system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test. If the air handler is not installed at the time of the test, total leakage shall be less than or equal to 4 cfm per 100 square feet of conditioned floor area.

EXCEPTIONS: 1. Duct tightness test is not required if the air handler and all ducts are located within conditioned space.

2. Duct tightness test is not required if the furnace is a nondirect vent type combustion appliance installed in an unconditioned space. A maximum of six feet of connected ductwork in the unconditioned space is allowed. All additional supply and return ducts shall be within the conditioned space. Ducts outside the conditioned space shall be sealed with a mastic type duct sealant and insulated on the exterior with R-8 insulation for above grade ducts and R-5 water resistant insulation when within a slab or earth.

503.10.4 Dampers: Requirements for automatic or manual dampers are found in Chapter 15 of the Washington State Residential Code (WAC 51-51).

503.11 Pipe Insulation: All piping shall be thermally insulated in accordance with Table 5-12.

EXCEPTION: Piping installed within unitary HVAC equipment.

Cold water pipes outside the conditioned space shall be insulated in accordance with the Washington State Plumbing Code (Chapter 51-56 WAC).

SECTION 504 — DOMESTIC WATER SYSTEMS

504.1 Scope: The purpose of this section is to provide criteria for design and equipment selection that will produce energy savings when applied to domestic water systems.

504.2 Water Heaters, Storage Tanks and Boilers

504.2.1 Performance Efficiency: Domestic water heating equipment shall comply with the applicable efficiencies listed in Tables 14-1A through 14-1G. All electric water heaters in unheated spaces or on concrete floors shall be placed on an incompressible, insulated surface with a minimum thermal resistance of R-10.

For combination space and service water heaters with a principal function of providing space heat, the Combined Annual Efficiency (CAE) may be calculated by using ASHRAE Standard 124-1991. Storage water heaters used in combination space heat and water heat applications shall have either an Energy Factor (EF) or a Combined Annual Efficiency (CAE) of not less than the following:

	Energy Factor (EF)	Combined Annual Efficiency (CAE)
< 50 gallon storage	0.58	0.71
50 to 70 gallon storage	0.57	0.71
> 70 gallon storage	0.55	0.70

504.2.2 Insulation: Heat loss from unfired hot-water storage tanks shall be limited to a maximum of 9.6 Btu/h/ft^2 of external tank surface area. The design ambient temperature shall be no higher than 65°F.

504.2.3 Combination Service Water Heating/Space Heating Boilers: Service water heating equipment shall not be dependent on year round operation of space heating boilers.

EXCEPTIONS: 1. Systems with service/space heating boilers having a standby loss Btu/h less than:

$$(13.3 \text{ pmd} + 400)/n$$

determined by the fixture count method where:

pmd = probable maximum demand in gallons/hour as determined in accordance with Chapter 49 of Standard RS-11.

n = fraction of year when outdoor daily mean temperature exceeds 64.9°F.

The standby loss is to be determined for a test period of 24 hours duration while maintaining a boiler water temperature of 90°F above an ambient of 60°F and a five foot stack on appliance.

2. For systems where the use of a single heating unit will lead to energy savings, such unit shall be utilized.

504.3 Automatic Controls: Service water heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use. Temperature setting range shall be set to 120°F or 49°C.

504.4 Shutdown: A separate switch shall be provided to permit turning off the energy supplied to electric service water heating systems. A separate valve shall be provided to permit turning off the energy supplied to the main burner(s) of all other types of service water heater systems.

504.5 Swimming Pools

504.5.1 Controls: All pool heaters shall be equipped with readily accessible ON/OFF switch to allow shutting off the operation of the heater without adjusting the thermostat setting. Controls shall be provided to allow the water temperature to be regulated from the maximum design temperature down to 65°F.

504.5.2 Residential Pool Pumps

504.5.2.1 Motor Efficiency: Pool pump motors may not be split-phase or capacitor start-induction run type.

504.5.2.2 Two-Speed Capability:

1. Pump motors: Pool pump motors with a capacity of 1 hp or more shall have the capability of operating at two or more speeds with low speed having a rotation rate that is no more than one-half of the motor's maximum rotation rate.

2. Pump controls: Pool pump motor controls shall have the capability of operating the pool pump with at least two speeds. The default circulation speed shall be the lowest speed, with a high speed override capability being for a temporary period not to exceed one normal cycle.

504.5.2.3 Portable Electric Spas: The standby power of portable electric spas shall not be greater than 5(V2/3) watts where V = the total volume, in gallons.

504.5.3 Pool Covers: Heated swimming pools shall be equipped with a pool cover, approved by the building official.

504.6 Pump Operation: Circulating water systems shall be controlled so that the circulation pump(s) can be conveniently turned off, automatically or manually, when the water system is not in operation.

504.7 Pipe Insulation: Piping shall be thermally insulated in accordance with Section 503.11.

504.8 Conservation of Water

504.8.1 Showers and Lavatories: Showers and lavatories used for other than safety reasons shall be equipped with flow control devices or specially manufactured shower-heads or aerators to limit the total water flow rate as set forth in Chapter 51-56 WAC, as measured with both hot and cold faucets turned on to their maximum flow.

SECTION 505 — LIGHTING

505.1 Interior Lighting: A minimum of 50 percent of all luminaires shall be high efficacy luminaires.

EXCEPTION: Lighting that complies with the Prescriptive Lighting Option in Section 1520 or the Lighting Power Allowance Option in Section 1530.

505.2 Exterior Lighting: Luminaires providing outdoor lighting and permanently mounted to a residential building or to other buildings on the same lot shall be high efficacy luminaires.

EXCEPTIONS: 1. Permanently installed outdoor luminaires that are not high efficacy shall be allowed provided they are controlled by a motion sensor(s) with integral photocontrol photosensor.

2. Permanently installed luminaires in or around swimming pools, water features.

505.3 Linear Fluorescent Fixtures: Linear fluorescent fixtures must be fitted with T-8 or smaller lamps (but not T-10 or T-12 lamps).

EQUATION 1 — SINGLE-FAMILY RESIDENTIAL TARGET UA

$$UA_T = U_W A_W + U_{BGW} A_{BGW} + U_{VG} A_{VG} + U_{OG} A_{OG} + U_F A_F + U_{RC} A_{RC} + U_D A_D + F_S P_S$$

Where:

UA_T = the target combined thermal transmittance of the gross exterior wall, floor and roof/ceiling assembly area.

U_W = the thermal transmittance value of the opaque above grade wall area found in Table 5-1.

A_W = opaque above grade wall area.

U_{BGW} = the thermal transmittance value of the below grade opaque wall area found in Table 5-1.

A_{BGW} = opaque below grade wall area.

U_{VG} = the thermal transmittance value of the vertical glazing area found in Table 5-1.

A_{VG} = 15% of the total floor area of the conditioned space minus A_{OG}.

U_{OG} = the thermal transmittance value of the overhead glazing area found in Table 5-1.

A_{OG} = overhead glazing area (if the proposed A_{OG} exceeds 15 percent, the target A_{OG} shall be 15 percent of the total floor area of the conditioned space).

U_F = the thermal transmittance value of the floor area found in Table 5-1.

A_F = floor area over unconditioned space.

U_{RC} = the thermal transmittance value of the roof/ceiling area found in Table 5-1.

A_{RC} = roof/ceiling area.

U_D = the thermal transmittance value of the opaque door area found in Table 5-1.

A_D = opaque door area.

F_S = concrete slab component F-factor found in Table 5-1.

P_S = lineal ft. of concrete slab perimeter.

EQUATION 2 — ALL OCCUPANCIES

$$U = \frac{1}{r_o + R_1 + R_2 \ldots r_i}$$

Where:

U = the thermal transmittance of the assembly.

r_o = outside air film resistance.

r_o = 0.17 for all exterior surfaces.

r_i = inside air film resistance.

r_i = 0.61 for interior horizontal surfaces, heat flow up.

r_i = 0.92 for interior horizontal surfaces, heat flow down.

r_i = 0.68 for interior vertical surfaces.

R = $\frac{1}{C} = \frac{X}{K}$ = measure of the resistance to the passage of heat for each element.

C = conductance, the heat flow through a specific material of specific thickness.

K = insulation value of a material per inch.

X = the thickness of the material in inches.

EQUATION 3 — SINGLE-FAMILY RESIDENTIAL PROPOSED UA

$$UA = U_W A_W + U_{BGW} A_{BGW} + U_{VG} A_{VG} + U_{OG} A_{OG} + U_F A_F + U_{RC} A_{RC} + U_D A_D + F_S P_S$$

Where:

UA	=	the combined thermal transmittance of the gross exterior wall, floor and roof/ceiling assembly area.
U_W	=	the thermal transmittance of the opaque wall area.
A_W	=	opaque wall area.
U_{BGW}	=	the thermal transmittance value of the below grade opaque wall area.
A_{BGW}	=	opaque below grade wall area.
U_{VG}	=	the thermal transmittance value of the vertical glazing area.
A_{VG}	=	vertical glazing area, including windows in exterior doors.
U_{OG}	=	the thermal transmittance value of the overhead glazing area.
A_{OG}	=	overhead glazing area.
U_F	=	the thermal transmittance of the floor area.
A_F	=	floor area over unconditioned space.
U_{RC}	=	the thermal transmittance of the roof/ceiling area.
A_{RC}	=	roof/ceiling area.
U_D	=	the thermal transmittance value of the opaque door area.
A_D	=	opaque door area.
F_S	=	concrete slab component F-factor.
P_S	=	lineal ft. of concrete slab perimeter.

NOTE: Where more than one type of wall, window, roof/ceiling, door and skylight is used, the U and A terms for those items shall be expanded into sub-elements as:

$$U_{W1}A_{W1} + U_{W2}A_{W2} + U_{W3}A_{W3} + ...\text{etc.}$$

EQUATION 4 — RESERVED

EQUATION 5 — RESERVED

TABLE 5-1
TARGET COMPONENT VALUES FOR SINGLE-FAMILY RESIDENTIAL

Component	Climate Zone 1	Climate Zone 2
Glazing % Floor Area	15%	15%
Vertical Glazing U-Factor	U = 0.30	U = 0.30
Overhead Glazing U-Factor	U = 0.50	U = 0.50
Doors	U = 0.200	U = 0.200
Ceilings	U = 0.027	U = 0.027
Walls	U = 0.056	U = 0.056
Floors	U = 0.029	U = 0.029
Slab on Grade	F = 0.36	F = 0.36
Below Grade		
Wall R-Value	R-21	R-21
2' Depth: Walls Slab	U = 0.042 F = 0.59	U = 0.042 F = 0.59
3.5' Depth: Walls Slab	U = 0.041 F = 0.64	U = 0.041 F = 0.64
7' Depth: Walls Slab	U = 0.037 F = 0.57	U = 0.037 F = 0.57

Log and solid timber walls that have a minimum average thickness of 3.5" in spaces with space heating by "other fuels" are exempt from wall target UA and proposed UA calculations.

TABLE 5-2 RESERVED

TABLE 5-3 RESERVED

TABLE 5-4 RESERVED

TABLE 5-5 RESERVED

TABLE 5-6 RESERVED

TABLE 5-7 RESERVED

TABLE 5-8 RESERVED

TABLE 5-9 RESERVED

TABLE 5-10 RESERVED

TABLE 5-11
INSULATION OF DUCTS

Duct Location	Climate Zone	Single Family Residential Heating or Cooling Ducts
On roof or on exterior of building	1	E and W
	2	D and W
Attic, garage, crawl space, in walls[1], in floor/ceiling[1]	1	E
	2	E
Within the conditioned space or in heated basements		None Required
In cement slab or in ground		B

Note: Where ducts are used for both heating and cooling, the minimum insulation shall be as required for the most restrictive condition.

1 Insulation may be omitted on that portion of a duct which is located within a wall or floor/ceiling space where both sides of this space are exposed to conditioned air and where this space is not ventilated or otherwise exposed to unconditioned air. ⇦

INSULATION TYPES: Minimum densities and out-of-package thickness.

A. 0.5-inch 1.5 to 2 lb/cu. ft. duct liner, mineral or glass fiber blanket or equivalent to provide an installed total thermal resistance of at least R-2.

B. 2-inch 0.60 lb/cu. ft. mineral or glass fiber blanket, 1.5-inch 1.5 to 2 lb/cu. ft. duct liner, mineral or glass fiber blanket. 1.5-inch 3 to 7 lb/cu. ft. mineral or glass fiber board or equivalent to provide an installed total thermal resistance of at least R-5.

C. 3-inch 0.60 lb/cu. ft. mineral or glass fiber blanket, 2-inch 1.5 to 2 lb/cu. ft. duct liner, mineral or glass fiber blanket. 2-inch 3 to 7 lb/cu. ft. mineral or glass fiber board or equivalent to provide an installed total thermal resistance of at least R-7.

D. 4-inch 0.60 lb/cu. ft. mineral or glass fiber blanket, 3-inch 1.5 to 2 lb/cu. ft. duct liner, mineral or glass fiber blanket. 3-inch 3 to 7 lb/cu. ft. mineral or glass fiber board or equivalent to provide an installed total thermal resistance of at least R-10.

E. 3.5-inch 0.60 lb/cu. ft. mineral or glass fiber blanket, 2.5-inch 1.5 to 2 lb/cu. ft. duct liner, mineral or glass fiber board or equivalent to provide an installed total thermal resistance of at least R-8. ⇦

W. Approved weatherproof barrier.

TABLE 5-12
MINIMUM PIPE INSULATION THICKNESS[1]

Fluid Design Operating Temp. Range, °F	Insulation Conductivity		Nominal Pipe or Tube Size (in.)				
	Conductivity Range Btu • in./(h • ft² • °F)	Mean Rating Temp. °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥ 8
Heating Systems (Steam, Steam Condensate and Hot water)[2]							
≥350	0.32-0.34	250	3.0	3.5	3.5	4.5	4.5
251-350	0.29-0.32	200	2.0	3.0	3.5	3.5	3.5
201-250	0.27-0.30	150	2.0	2.0	2.5	2.5	2.5
141-200	0.25-0.29	125	1.5	1.5	1.5	2.0	2.0
105-140	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
Domestic and Service Hot Water Systems							
≥105	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine and Refrigerant)							
40-60	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
≤40	0.22-0.28	100	1.0	1.5	1.5	1.5	2.0

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

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

Where

T = Minimum insulation thickness (in.)
r = Actual outside radius of pipe (in.)
t = Insulation thickness from Table 5-12 for applicable fluid temperature and pipe size
K = Conductivity of alternate material at the mean rating temperature indicated for the applicable fluid temperature, Btu • in/(h • ft² • °F)
k = The upper value of the conductivity range listed in Table 5-12 for the applicable fluid temperature

2. Piping insulation is not required between the control valve and coil on Runouts when the control valve is located within 4 feet of the coil and the pipe size is 1 inch or less.

TABLE 5-13 RESERVED

CHAPTER 6
BUILDING DESIGN
BY PRESCRIPTIVE REQUIREMENTS APPROACH

SECTION 601 — SCOPE

601.1 General: This chapter establishes design criteria in terms of prescribed requirements for building construction.

The provisions of this chapter are applicable to all Single-Family residential dwellings. Spaces shall comply with all the requirements of Chapter 5 except for the modifications herein specified. In addition, the design shall comply with the additional energy efficiency requirements of Chapter 9.

For duplexes and townhouses, compliance shall be shown on a dwelling-unit by dwelling-unit basis. Averaging is not allowed.

For wood frame assemblies, the building envelope requirements of this chapter may be met by installing one of the prescriptive packages in Table 6-1 or 6-2. Installed components shall meet the requirements of Section 602. Compliance with nominal R-values shall be demonstrated for the thermal resistance of the added insulation in framing cavities and/or insulated sheathing only and shall not include the thermal transmittance of other building materials or air films, but shall permit interruption by occasional framing members. Other than wood frame assemblies with continuous insulation uninterrupted by framing shall also be allowed to comply with nominal R-values.

For metal assemblies, compliance shall be demonstrated in accordance with Chapter 4 or Chapter 5 based on the assemblies in Chapter 10. Compliance with nominal R-values is not allowed, unless the full nominal R-value of the insulation is installed either inside or outside of the framing and is uninterrupted by framing.

SECTION 602 — BUILDING ENVELOPE REQUIREMENTS FOR SINGLE-FAMILY RESIDENTIAL

602.1 Roof/Ceiling: Ceilings below vented attics and single-rafter, joist-vaulted ceilings shall be insulated to not less than the nominal R-value specified for ceilings in Table 6-1 or 6-2 as applicable.

602.2 Exterior Walls Both Above and Below Grade: Above grade exterior walls shall be insulated to not less than the nominal R-value specified in Table 6-1 or 6-2 as applicable. The following walls should be considered to meet R-21 without additional documentation:

1. 2 x 6 framed and insulated with R-21 fiberglass batts.
2. 2 x 4 framed and insulated with R-15 fiberglass batts plus R-4.0 foam sheathing.
3. 2 x 4 framed and insulated with R-13 fiberglass batts plus R-5.0 foam sheathing.
4. 2 x 6 framed and insulated to full depth with spray applied or blown insulation having a minimum R-value of 3.6 per inch of thickness.

602.3 Exterior Walls (Below-Grade): Below-grade exterior walls surrounding conditioned space shall be insulated to not less than the nominal R-value specified for below-grade walls in Table 6-1 or 6-2 as applicable.

602.4 Slab-on-Grade Floors: Slab-on-grade floors shall be insulated along their perimeter to not less than the nominal R-values specified for slab-on-grade floors in Table 6-1 or 6-2 as applicable. Slab insulation shall be installed in compliance with Section 502.1.4.8. See Chapter 5, Section 502.1.4.9, for additional requirements for radiant slab heating.

602.5 Floors Over Unconditioned Space: Floors over unconditioned spaces, such as vented crawl spaces, unconditioned basements, and parking garages shall be insulated to not less than the nominal R-value shown for floors over unconditioned spaces in Table 6-1 or 6-2.

602.6 Exterior Doors: Doors shall comply with Sections 602.6.1 and 602.6.2.

EXCEPTIONS: 1. Glazed doors whose area and U-factor are included in the calculations for compliance with the requirements for glazing in Section 602.7 shall be exempt from the door U-factor requirements prescribed in Table 6-1 or 6-2.

2. One unlabeled or untested exterior swinging door with the maximum area of 24 square feet may be installed per unit for ornamental, security, or architectural purposes. Products using this exception shall not be included in either the U-factor or glazing area calculation requirements.

602.6.1 Exterior Door Area: For half-lite and full-lite doors, the glazing area shall be included in calculating the allowed total glazing area in Section 602.7.1. ⇦

602.6.2 Exterior Door U-Factor: Doors, including fire doors, shall have a maximum area weighted average U-factor not exceeding that prescribed in Table 6-1 or 6-2.

602.7 Glazing

602.7.1 Glazing Area: The total glazing area as defined in Chapter 2 shall not exceed the percentage of gross conditioned floor area specified in Table 6-1 or 6-2. This area shall also include any glazing in doors.

602.7.2 Glazing U-Factor: The total glazing area as defined in Chapter 2 shall have an area weighted average U-factor not to exceed that specified in Table 6-1 or 6-2. U-factors for glazing shall be determined in accordance with Section 502.1.5. These areas and U-factors shall also include any doors using the exception of Section 602.6.

If the U-factors for all vertical and overhead glazing products are below the appropriate U-factor specified, then no calculations are required. If compliance is to be achieved through an area weighted calculation, then the areas and U-factors shall be included in the plans submitted with a building permit application.

EXCEPTION: Double glazed garden windows with a wood or vinyl frame shall be exempt from the U-factor calculations but shall have its area tripled and shall be included in the percentage of the total glazing area as allowed for in Table 6-1 or 6-2. The maximum area (before tripling) allowed for the total of all garden windows is 1% of the floor area or 20 square feet, whichever is less.

602.8 Air Leakage for Single-Family Residential: The minimum air leakage control measures shall be as specified in Section 502.4 as applicable, including building envelope air leakage testing.

SECTION 603 — BUILDING MECHANICAL SYSTEMS FOR SINGLE-FAMILY RESIDENTIAL

603.1 Spaces that are heated by air-to-air, ground-to-air or water-to-air heat pumps shall comply with Table 6-1 or 6-2. System sizing shall be determined by an analysis consistent with Section 503.2 of this Code. All mechanical equipment efficiencies shall comply with standards as stated in Section 503 of this Code.

SECTION 604 — DOMESTIC WATER SYSTEMS.

Domestic water systems, including plumbing fixtures and appliances, shall comply with Section 504.

SECTION 605 — LIGHTING

Lighting shall comply with Section 505.

TABLE 6-1
PRESCRIPTIVE REQUIREMENTS[0,1] FOR SINGLE-FAMILY RESIDENTIAL
CLIMATE ZONE 1

Option	Glazing Area[10]: % of Floor	Glazing U-Factor		Door[9] U-Factor	Ceiling[2]	Vaulted Ceiling[3]	Wall[12] Above Grade	Wall• int[4] Below Grade	Wall• ext[4] Below Grade	Floor[5]	Slab[6] on Grade
		Vertical	Overhead[11]								
I.	13%	0.34	0.50	0.20	R-49 or R-38 adv	R-38	R-21 int[7]	R-21 TB	R-10	R-30	R-10 2'
II.*	25%	0.32	0.50	0.20	R-49 or R-38 adv	R-38	R-21 int[7]	R-21 TB	R-10	R-30	R-10 2'
III.	Unlimited	0.30	0.50	0.20	R-49 or R-38 adv	R-38	R-21 int[7]	R-21 TB	R-10	R-30 / U=0.029	R-10 2'

* Reference Case

0. Nominal R-values are for wood frame assemblies only or assemblies built in accordance with Section 601.1.

1. Minimum requirements for each option listed. For example, if a proposed design has a glazing ratio to the conditioned floor area of 13%, it shall comply with all of the requirements of the 15% glazing option (or higher). Proposed designs which cannot meet the specific requirements of a listed option above may calculate compliance by Chapters 4 or 5 of this Code.

2. Requirement applies to all ceilings except single rafter or joist vaulted ceilings complying with note 3. 'Adv' denotes Advanced Framed Ceiling.

3. Requirement applicable only to single rafter or joist vaulted ceilings. ⇦

4. Below grade walls shall be insulated either on the exterior to a minimum level of R-10 continuous, or on the interior as a framed wall. Exterior insulation installed on below grade walls shall be a water resistant material, manufactured for its intended use, and installed according to the manufacturer's specifications. See Section 602.2.

5. Floors over crawl spaces or exposed to ambient air conditions.

6. Required slab perimeter insulation shall be a water resistant material, manufactured for its intended use, and installed according to manufacturer's specifications. See Section 602.4. For slabs inside a foundation wall, the insulation shall be installed to provide a thermal break (TB) between the slab edge and the foundation. Monolithic slabs shall include insulation, installed outside the foundation wall, and shall extend downward from the top of the slab for a minimum distance of 24 inches or downward and then horizontally for a minimum combined distance of 24 inches. Monolithic slabs shall also include R-10 insulation under the non-load-bearing portions of the slab.

7. Int. denotes standard framing 16 inches on center with headers insulated with a minimum of R-10 insulation.

8. Reserved. ⇦

9. Doors, including all fire doors, shall be assigned default U-factors from Table 10-6C.

10. Where a maximum glazing area is listed, the total glazing area (combined vertical plus overhead) as a percent of gross conditioned floor area shall be less than or equal to that value. Overhead glazing with U-factor of U=0.35 or less is not included in glazing area limitations.

11. Overhead glazing shall have U-factors determined in accordance with NFRC 100 or as specified in Section 502.1.5.

12. Log and solid timber walls with a minimum average thickness of 3.5" are exempt from this insulation requirement.

TABLE 6-2
PRESCRIPTIVE REQUIREMENT S[0,1] FOR SINGLE-FAMILY RESIDENTIAL
CLIMATE ZONE 2

Option	Glazing Area[10]: % of Floor	Glazing U-Factor		Door[9] U-Factor	Ceiling[2]	Vaulted Ceiling[3]	Wall[12] Above Grade	Wall int[4] Below Grade	Wall ext[4] Below Grade	Floor[5]	Slab[6] on Grade
		Vertical	Overhead[11]								
I.	12%	0.32	0.50	0.20	R-49 or R-38 adv	R-38	R-21 int[7]	R-21 TB	R-12	R-30	R-10 2'
II.*	15%	0.32	0.50	0.20	R-49 or R-38 adv	R-38	R-19 + R-5	R-21 TB	R-12	R-30	R-10 2'
III.	Unlimited	0.30	0.50	0.20	R-49 or R-38 adv	R-38	R-19 + R-5	R-21 TB	R-12	R-30	R-10 2'

* Reference Case

0. Nominal R-values are for wood frame assemblies only or assemblies built in accordance with Section 601.1.

1. Minimum requirements for each option listed. For example, if a proposed design has a glazing ratio to the conditioned floor area of 13%, it shall comply with all of the requirements of the 15% glazing option (or higher). Proposed designs which cannot meet the specific requirements of a listed option above may calculate compliance by Chapters 4 or 5 of this Code.

2. Requirement applies to all ceilings except single rafter or joist vaulted ceilings complying with note 3. 'Adv' denotes Advanced Framed Ceiling.

3. Requirement applicable only to single rafter or joist vaulted ceilings. ⇦

4. Below grade walls shall be insulated either on the exterior to a minimum level of R-12 continuous, or on the interior as a framed wall. Exterior insulation installed on below grade walls shall be a water resistant material, manufactured for its intended use, and installed according to the manufacturer's specifications. See Section 602.2.

5. Floors over crawl spaces or exposed to ambient air conditions.

6. Required slab perimeter insulation shall be a water resistant material, manufactured for its intended use, and installed according to manufacturer's specifications. See Section 602.4. For slabs inside a foundation wall, the insulation shall be installed to provide a thermal break (TB) between the slab edge and the foundation. Monolithic slabs shall include insulation, installed outside the foundation wall, and shall extend downward from the top of the slab for a minimum distance of 24 inches or downward and then horizontally for a minimum combined distance of 24 inches. Monolithic slabs shall also include R-10 insulation under the non-load-bearing portions of the slab.

7. Int. denotes standard framing 16 inches on center with headers insulated with a minimum of R-10 insulation.

8. Reserved. ⇦

9. Doors, including all fire doors, shall be assigned default U-factors from Table 10-6C.

10. Where a maximum glazing area is listed, the total glazing area (combined vertical plus overhead) as a percent of gross conditioned floor area shall be less than or equal to that value. Overhead glazing with U-factor of U=0.35 or less is not included in glazing area limitations.

11. Overhead glazing shall have U-factors determined in accordance with NFRC 100 or as specified in Section 502.1.5.

12. Log and solid timber walls with a minimum average thickness of 3.5" are exempt from this insulation requirement.

CHAPTER 7
STANDARDS

SECTION 701 — STANDARDS

The following standards shall apply to Chapters 1 through 20. The standards and portions thereof, which are referred to in various parts of this Code shall be part of the Washington State Energy Code and are hereby declared to be a part of this Code.

CODE STANDARD NO.	TITLE AND SOURCE
RS-1	2005 ASHRAE Fundamentals Handbook.
RS-2	Super Good Cents Technical Reference (Builder's Field Guide)
RS-3:	(Reserved.) ⇦
RS-4	ASHRAE Standard 55-2004 Thermal Environmental Conditions for Human Occupancy.
RS-5	2006 ASHRAE Refrigeration Handbook
RS-6	(Reserved.)
RS-7	SMACNA, HVAC Duct Construction Standards, Metal and Flexible, 2005.
RS-8:	(Reserved.) ⇦
RS-9	ASHRAE/IESNA Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings.
RS-10	2008 ASHRAE Systems and Equipment Handbook.
RS-11	2007 ASHRAE HVAC Applications Handbook.
RS-12 – RS-28:	(Reserved.)
RS-29	Nonresidential Building Design by Systems Analysis.
RS-30	Title 10, Code of Federal Regulations (CFR), Part 430 (March 14, 1988).
RS-31	National Fenestration Rating Council (NFRC) Standard 100-2004.
RS-32	Seattle EnvStd 2006
RS-33	Duct Testing Standard for New and Existing Construction, WSU Extension Energy Program Publication #WSUEEP 09-008.
RS-34	Optional Acceptance Requirements for Nonresidential Buildings, SBCC 2009.

ACCREDITED AUTHORITATIVE AGENCIES

ANSI refers to the American National Standards Institute, Inc., 11 West 42nd Street, New York, NY 10036
Phone (212) 642-4900 Fax (212) 398-0023, Internet www.ansi.org

AHRI refers to the Air-Conditioning, Heating and Refrigeration Institute, 4301 N. Fairfax Dr., Suite 425, Arlington, VA 22203
Phone (703) 524-8800 Fax (703) 528-3816, Internet www.ari.org

ASHRAE refers to the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329
Phone (404) 636-8400 Fax (404) 321-5478, Internet www.ashrae.org

ASTM refers to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959
Phone (610) 832-9585 Fax (610) 832-9555, Internet www.astm.org

CTI refers to the Cooling Tower Institute, 530 Wells Fargo Drive, Suite 218, Houston, TX 77090
Phone (281) 583-4087 Fax (281) 537-1721, Internet www.cti.org

IESNA refers to the Illuminating Engineering Society of North America, 120 Wall Street, Floor 17, New York, NY 10005-4001
Phone (212) 248-5000 Fax (212) 248-5017, Internet www.iesna.org

NFRC refers to the National Fenestration Rating Council, Inc., 8484 Georgia Avenue, Suite 320, Silver Spring, Maryland 20910
Phone (301) 589-1776 Fax (301) 589-3884, Internet www.nfrc.org

SBCC refers to the Washington State Building Code Council, PO Box 42525, Olympia, WA 98504-2525
Phone (360) 725-2990 Fax (360) 586-9383, Internet www.sbcc.wa.gov

SMACNA refers to the Sheet Metal and Air Conditioning Contractors National Association, Inc., 4201 Lafayette Center Drive, P.O. Box 221230, Chantilly, VA 20153-1230
Phone (703) 803-2980 Fax (703) 803-3732, Internet www.smacna.org

WSU refers to the Washington State University Energy Extension Program, 905 Plum Street SE, Bldg #3, PO Box 43165, Olympia, WA 98506-3166
Phone (360) 956-2000 Fax (360) 956-2217, Internet www.energy.wsu.edu

CHAPTER 8
SUGGESTED SOFTWARE FOR CHAPTER 4
SYSTEMS ANALYSIS APPROACH

The simulation program shall be tested according to ANSI/ASHRAE Standard 140 and the results shall be furnished by the software provider.

The following is a list of suggested software, but not limited to:

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

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

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

CHAPTER 9
ADDITIONAL SINGLE-FAMILY RESIDENTIAL ENERGY EFFICIENCY REQUIREMENTS

901 Additional Residential Energy Efficiency Requirements. Dwelling units permitted under this Code shall comply with all provisions of Chapter 5 of this Code and develop one credit from Table 9-1.

EXCEPTION: Buildings complying using Chapter 4 Building Design by Systems Analysis shall meet this provision of this section by demonstrating that the proposed building energy use is 16 percent less than the target building energy use.

TABLE 9-1
ENERGY CREDITS (DEBITS)

OPTION	DESCRIPTION	CREDIT(S)
1a	HIGH EFFICIENCY HVAC EQUIPMENT 1: Gas, propane or oil-fired furnace or boiler with minimum AFUE of 92%, **or** Air-source heat pump with minimum HSPF of 8.5.	1.0
1b	HIGH EFFICIENCY HVAC EQUIPMENT 2: Closed-loop ground source heat pump; with a minimum COP of 3.3.	2.0
1c	HIGH EFFICIENCY HVAC EQUIPMENT 3: DUCTLESS SPLIT SYSTEM HEAT PUMPS, ZONAL CONTROL: In home where the primary space heating system is zonal electric heating, a ductless heat pump system shall be installed and provide heating to at least one zone of the housing unit.	1.0
2	HIGH EFFICIENCY HVAC DISTRIBUTION SYSTEM:[1] All heating and cooling system components installed inside the conditioned space. All combustion equipment shall be direct vent or sealed combustion. Locating system components in conditioned crawl spaces is not permitted under this option. Electric resistance heat is not permitted under this option. Direct combustion heating equipment with AFUE less than 80% is not permitted under this option.	1.0
3a	EFFICIENT BUILDING ENVELOPE 1: Prescriptive compliance is based on Table 6-1, Option III with the following modifications: Window U .= 0.28 floor R-38, slab on grade R-10 full, below grade slab R-10 full. **or** Component performance compliance: Reduce the Target UA from Table 5-1 by 5%, as determined using EQUATION 1.[1]	0.5
3b	EFFICIENT BUILDING ENVELOPE 2: Prescriptive compliance is based on Table 6-1, Option III with the following modifications: Window U .= 0.25 and wall R-21 plus R-4 and R-38 floor, slab on grade R-10 full, below grade slab R-10 full, and R-21 plus R-5 below grade basement walls. **or** Component performance compliance: Reduce the Target UA from Table 5.1 by 15%, as determined using EQUATION 1.[1]	1.0

3c	SUPER-EFFICIENT BUILDING ENVELOPE 3: Prescriptive compliance is based on Table 6-1, Option III with the following modifications: Window U .= 0.22 and wall R-21 plus R-12 and R-38 floor, slab on grade R-10 full, below grade slab R-10 full and R-21 plus R-12 below grade basement walls and R-49 advanced ceiling and vault. **or** Component performance compliance: Reduce the Target UA from Table 5.1 by 30%, as determined using EQUATION 1.[1]	2.0
4a	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION: Envelope leakage reduced to SLA of 0.00020 building envelope tightness shall be considered acceptable when tested air leakage is less than specific leakage area of 0.00020 when tested with a blower door at a pressure difference of 50 PA. Testing shall occur after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation, and combustion appliances. **and** All whole house ventilation requirements as determined by Section M1508 of the Washington State Residential Code shall be met with a heat recovery ventilation system in accordance with Section M1508.7 of that Code.	0.5
4b	ADDITIONAL AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION: Envelope leakage reduced to SLA of 0.00015 building envelope tightness shall be considered acceptable when tested air leakage is less than specific leakage area of 0.00015 when tested with a blower door at a pressure difference of 50 PA. Testing shall occur after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation, and combustion appliances. **and** All whole house ventilation requirements as determined by Section M1508 of the Washington State Residential Code shall be met with a heat recovery ventilation system in accordance with Section M1508.7 of that Code.	1.0
5a	EFFICIENT WATER HEATING:[1] Water heating system shall include one of the following: Gas, propane or oil water heater with a minimum EF of 0.62. **or** Electric Water Heater with a minimum EF of 0.93. **and for both cases** All showerhead and kitchen sink faucets installed in the house shall meet be rated at 1.75 GPM or less. All other lavatory faucets shall be rated at 1.0 GPM or less.[2]	0.5

5b	HIGH EFFICIENCY WATER HEATING:[1] Water heating system shall include one of the following: Gas, propane or oil water heater with a minimum EF of 0.82. **or** Solar water heating supplementing a minimum standard water heater. Solar water heating will provide a rated minimum savings of 85 therms or 2000 kWh based on the Solar Rating and Certification Corporation (SRCC) Annual Performance of OG-300 Certified Solar Water Heating Systems. **or** Electric heat pump water heater with a minimum EF of 2.0.	1.5
6	SMALL DWELLING UNIT 1:[1] Dwelling units less than 1500 square feet in floor area with less than 300 square feet of window + door area. Additions to existing building that are less than 750 square feet of heated floor area.	1.0
7	LARGE DWELLING UNIT 1:[1] Dwelling units exceeding 5000 square feet of floor area shall be assessed a deduction for purposes of complying with Section 901 of this Code.	-1.0
8	RENEWABLE ELECTRIC ENERGY: For each 1200 kWh of electrical generation provided annually by on-site wind or solar equipment a 0.5 credit shall be allowed, up to 3 credits. Generation shall be calculated as follows: For solar electric systems, the design shall be demonstrated to meet this requirement using the National Renewable Energy Laboratory calculator PVWATTs. Documentation noting solar access shall be included on the plans. For wind generation projects designs shall document annual power generation based on the following factors: The wind turbine power curve; average annual wind speed at the site; frequency distribution of the wind speed at the site and height of the tower.	0.5

Footnotes:

1. **Interior Duct Placement:** Ducts included as Option 2 of Table 9-1 shall be placed wholly within the heated envelope of the housing unit. The placement shall be inspected and certified to receive the credits associated with this option.

EXCEPTION: Ducts complying with this section may have up to 5% of the total linear feet of ducts located in the exterior cavities or buffer spaces of the dwelling. If this exception is used the ducts will be tested to the following standards:

Post-construction test: Leakage to outdoors shall be less than or equal to 1 CFM per 100 ft^2 of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test.

2. **Plumbing Fixtures Flow Ratings.** Low flow plumbing fixtures (water closets and urinals) and fittings (faucets and showerheads) shall comply with the following requirements:

(a) Residential bathroom lavatory sink faucets: Maximum flow rate - 3.8 L/min (1.0 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(b) Residential kitchen faucets: Maximum flow rate - 6.6 L/min (1.75 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(c) Residential showerheads: Maximum flow rate - 6.6 L/min (1.75 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

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CHAPTER 10
DEFAULT HEAT LOSS COEFFICIENTS

SECTION 1001 — GENERAL

1001.1 Scope: The following defaults shall apply to Chapters 1 through 20. This chapter includes tables of seasonal average heat loss coefficients for specified nominal insulation. The heat loss coefficients may also be used for heating system sizing.

1001.2 Description: These coefficients were developed primarily from data and procedures from Standard RS-1, and taken specifically from Standard RS-2, listed in Chapter 7.

Coefficients not contained in this chapter may be computed using the procedures listed in these references if the assumptions in the following sections and Standard RS-2, listed in Chapter 7, are used, along with data from the sources referenced above.

1001.3 Air Films: Default R-values used for air films shall be as follows:

R-Value	Condition
0.17	All exterior surfaces
0.61	Interior horizontal surfaces, heat flow up
0.92	Interior horizontal surfaces, heat flow down
0.68	Interior vertical surfaces

1001.4 Compression of Insulation: Insulation which is compressed shall be rated in accordance with Table 10-A or reduction in value may be calculated in accordance with the procedures in Standard RS-1, listed in Chapter 7.

SECTION 1002 — BELOW-GRADE WALLS AND SLABS

1002.1 General: Table 10-1 lists heat loss coefficients for below-grade walls and floors.

Coefficients for below-grade walls are given as U-factors (Btu/h•ft^2•°F of wall area). Coefficients for below-grade slabs are listed as F-factors (Btu/h• ft•°F per lineal foot of slab perimeter).

Below-grade wall U-factors are only valid when used with the accompanying below-grade slab F-factor, and vice versa.

1002.2 Component Description: All below-grade walls are assumed to be 8 inch concrete. The wall is assumed to extend from the slab upward to the top of the mud sill for the distance specified in Table 10-1, with 6 inches of concrete wall extending above grade.

Interior insulation is assumed to be fiberglass batts placed in the cavity formed by 2x4 framing on 24 inch centers with 1/2 inch gypsum board as the interior finish material. Exterior insulation is assumed to be applied directly to the exterior of the below-grade wall from the top of the wall to the footing. The exterior case does not assume any interior framing or sheetrock.

In all cases, the entire wall surface is assumed to be insulated to the indicated nominal level with the appropriate framing and insulation application. Coefficients are listed for wall depths of 2, 3-1/2 and 7 feet below grade. Basements shallower than two feet should use on-grade slab coefficients.

Heat-loss calculations for wall areas above-grade should use above-grade wall U-factors, beginning at the mudsill.

1002.3 Insulation Description: Coefficients are listed for the following four configurations:

1. **Uninsulated:** No insulation or interior finish.
2. **Interior insulation:** Interior 2x4 insulated wall without a thermal break between concrete wall and slab.
3. **Interior insulation with thermal break:** Interior 2x4 insulated wall with R-5 rigid board providing a thermal break between the concrete wall and the slab.
4. **Exterior insulation:** Insulation applied directly to the exterior surface of the concrete wall.

TABLE 10-A
R-VALUE OF FIBERGLASS BATTS COMPRESSED WITHIN VARIOUS DEPTH CAVITIES

Insulation R-Values at Standard Thickness

Rated R-Value		82	71	60	49	38	30	22	21	19	15	13	11
Standard Thickness, Inches		26.0	22.5	19.0	15.5	12"	9.5	6.5	5.5	6	3.5	3.5	3.5
Nominal Lumber Sizes, Inches	Actual Depth of Cavity, Inches	Insulation R-Values When Installed in a Confined Cavity											
Truss	26.0	82	—	—	—	—	—	—	—	—	—	—	—
Truss	22.5	—	71	—	—	—	—	—	—	—	—	—	—
Truss	19.0	—	—	60	—	—	—	—	—	—	—	—	—
Truss	15.5	—	—	—	49	—	—	—	—	—	—	—	—
Truss	12.0	—	—	—	—	38	—	—	—	—	—	—	—
2x12	11.25	—	—	—	—	37	—	—	—	—	—	—	—
2x10	9.25	—	—	—	—	32	30	—	—	—	—	—	—
2x8	7.25	—	—	—	—	27	26	22	21	19	—	—	—
2x6	5.5	—	—	—	—	—	21	20	21	18	—	—	—
2x4	3.5	—	—	—	—	—	—	14	—	13	15	13	11
	2.5	—	—	—	—	—	—	—	—	—	—	9.8	—
	1.5	—	—	—	—	—	—	—	—	—	—	6.3	6.0

TABLE 10-1
DEFAULT WALL U-FACTORS AND SLAB F-FACTORS FOR BASEMENTS

	Below Grade Wall U-factor	Below Grade Slab F-factor
2 Foot Depth Below Grade		
Uninsulated	0.350	0.59
R-11 Interior	0.066	0.68
R-11 Interior w/tb	0.070	0.60
R-19 Interior	0.043	0.69
R-19 Interior w/tb	0.045	0.61
R-10 Exterior	0.070	0.60
R-12 Exterior	0.061	0.60
3.5 Foot Depth Below Grade		
Uninsulated	0.278	0.53
R-11 Interior	0.062	0.63
R-11 Interior w/tb	0.064	0.57
R-19 Interior	0.041	0.64
R-19 Interior w/tb	0.042	0.57
R-10 Exterior	0.064	0.57
R-12 Exterior	0.057	0.57
7 Foot Depth Below Grade		
Uninsulated	0.193	0.46
R-11 Interior	0.054	0.56
R-11 Interior w/tb	0.056	0.42
R-19 Interior	0.037	0.57
R-19 Interior w/tb	0.038	0.43
R-10 Exterior	0.056	0.42
R-12 Exterior	0.050	0.42

SECTION 1003 — ON-GRADE SLAB FLOORS

1003.1 General: Table 10-2 lists heat loss coefficients for heated on-grade slab floors, in units of Btu/h•°F per lineal foot of perimeter.

1003.2 Component Description: All on-grade slab floors are assumed to be 6 inch concrete poured directly onto the earth. The bottom of the slab is assumed to be at grade line. Monolithic and floating slabs are not differentiated.

Soil is assumed to have a conductivity of 0.75 Btu/h•ft^2•°F. Slabs 2 feet or more below grade should use basement coefficients.

1003.3 Insulation Description: Coefficients are provided for the following three configurations:

Two Foot (or four foot) vertical: Insulation is applied directly to the slab exterior, extending downward from the top of the slab to a depth of 2 feet (or 4 feet) below grade.

Two Foot (or four foot) horizontal: Insulation is applied directly to the underside of the slab, and run horizontally from the perimeter inward for 2 feet (or 4 feet). The slab edge is exposed in this configuration.

Note: A horizontal installation with a thermal break of at least R-5 at the slab edge should use the vertical-case F-factors.

Fully insulated slab: Insulation extends from the top of the slab, along the entire perimeter, and completely covers the area under the slab. Thicker perimeter insulation covers the slab edge and extends 2 feet under the slab.

TABLE 10-2
DEFAULT F-FACTORS FOR ON-GRADE SLABS

Insulation type	R-0	R-5	R-10	R-15
Unheated Slab				
Uninsulated slab	0.73	--	--	--
2 ft Horizontal (No thermal break)	--	0.70	0.70	0.69
4 ft Horizontal (No thermal break)	--	0.67	0.64	0.63
2 ft Vertical	--	0.58	0.54	0.52
4 ft Vertical	--	0.54	0.48	0.45
Fully insulated slab	--	--	0.36	--
Heated Slab				
Uninsulated slab	0.84	--	--	--
Fully insulated slab	--	0.74	0.55	0.44
R-5 Center (With perimeter insulation)	--	--	0.66	0.62
R-10 Center (With perimeter insulation)	--	--	--	0.51
3 ft Vertical	--	--	0.78	--

SECTION 1004 — FLOORS OVER UNCONDITIONED SPACE

1004.1 General: Tables 10-3, 10-4 and 10-4A list heat loss coefficients for floors over unconditioned spaces in units of Btu/h•ft²•°F.

They are derived from procedures listed in Standard RS-1, listed in Chapter 7, assuming an average outdoor temperature of 45°F, an average indoor temperature of 65°F and a crawlspace area of 1350 ft² and 100 feet of perimeter. The crawlspace is assumed to be 2.5 feet high, with 24 inches below grade and 6 inches above grade.

1004.2 Crawlspace Description: Four configurations are considered: naturally ventilated crawlspace, mechanically vented crawlspace, heated plenum crawlspace and exposed floor.

Naturally ventilated crawlspaces: Assumed to have 3.0 air changes per hour, with at least 1.0 ft² of net-free ventilation in the foundation for every 300 ft² of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated areas, such as garages, may only use those values which have R-0 perimeter insulation.

Mechanically ventilated crawlspaces: Assumed to have 1.5 air changes per hour, with less than 1.0 ft² of net-free ventilation in the foundation for every 300 ft² of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated basements may only use those values which have R-0 perimeter insulation.

Heated plenum crawlspaces: Assumed to have 0.25 air changes per hour, with no foundation vents. Heated supply air from central furnace is blown into a crawlspace and allowed to enter the living space unducted via holes cut into the floor.

Exposed floors: Assumes no buffer space, and a covering of 1/2 inch T1-11 on the exterior of the cavity exposed to the outside air or rigid insulation below a concrete floor, such as over parking garages.

1004.3 Construction Description: Floors are assumed to be either joisted floors framed on 16 centers, or post and beam on 4 foot by 8 foot squares. Insulation is assumed to be installed under the subflooring between the joists or beams with no space between the insulation and the subfloor. Insulation is assumed to be uncompressed. Exposed floors also include concrete with continuous rigid insulation assumed.

Perimeter insulation is assumed to extend from the top of the rim joist to the crawlspace floor and then inward along the ground (on top of the ground cover) for at least 24 inches.

Floor coverings are assumed to be light carpet with rubber pad.

TABLE 10-3
DEFAULT U-FACTORS FOR FLOORS OVER VENTED CRAWLSPACE OR UNHEATED BASEMENT

Nominal R-value		U-factor	
Floor	Perimeter	Post & Beam	Joists
0	0	0.112	0.134
	11	0.100	0.116
	19	0.098	0.114
	30	0.093	0.107
11	0	0.052	0.056
	11	0.048	0.052
19	0	0.038	0.041
	11	0.036	0.038
22	0	0.034	0.037
	11	0.033	0.035
25	0	0.032	0.034
	11	0.031	0.033
30	0	0.028	0.029
	11	0.027	0.028
38	0	0.024	0.025
	11	0.024	0.024

TABLE 10-4
DEFAULT U-FACTORS FOR FLOORS OVER HEATED PLENUM CRAWLSPACES

Nominal R-value Perimeter	U-factor
11	0.085
19	0.075
30	0.069

Note: Crawlspaces used as heated plenums have approximately 30% higher heat loss rate than unvented crawlspaces with the same assumed ACH. Default U-factors in Table 10-4 reflect this higher rate of heat loss.

TABLE 10-4A
DEFAULT U-FACTORS FOR EXPOSED FLOORS

Nominal	U-factor		
R-value	Concrete	Wood Joist	Metal Joist
R-11	0.077	0.088	0.14
R-15	0.059	0.076	0.12
R-19	0.048	0.062	0.11
R-21	0.043	0.057	0.11
R-25	0.037	0.051	0.10
R-30	0.031	0.040	0.09
R-38	0.025	0.034	0.08

SECTION 1005 — ABOVE-GRADE WALLS

1005.1 General: Table 10-5, 10-5A and 10-5B list heat loss coefficients for the opaque portion of above-grade wood stud frame walls, metal stud frame walls and concrete masonry walls (Btu/h•ft^2•°F) respectively. They are derived from procedures listed in Standard RS-1, listed in Chapter 7. For intermediate floor slabs which penetrate the insulated wall, use the concrete wall U-factors in Table 10-5B.

Insulation is assumed to uniformly fill the entire cavity and to be installed as per manufacturer's directions. All walls are assumed to be finished on the inside with 1/2 inch gypsum wallboard, and on the outside with either beveled wood siding over 1/2 inch plywood sheathing or with 5/8 inch T1-11 siding. Insulated sheathing (either interior or exterior) is assumed to cover the entire opaque wall surface.

Metal building walls have a different construction and are addressed in Table 10-5A(3).

1005.2 Framing Description: For wood stud frame walls, three framing types are considered and defined as follows:

Standard: Studs framed on 16 inch centers with double top plate and single bottom plate. Corners use three studs and each opening is framed using two studs. Headers consist of double 2x or single 4x material with an air space left between the header and the exterior sheathing. Interior partition wall/exterior wall intersections use two studs in the exterior wall.

Standard framing weighting factors:

Studs and plates	0.19
Insulated cavity	0.77
Headers	0.04

Intermediate: Studs framed on 16 inch centers with double top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and each opening is framed by two studs. Headers consist of double 2x material with R-10 insulation between the header and exterior sheathing. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Intermediate framing weighting factors:

Studs and plates	0.18
Insulated cavity	0.78
Headers	0.04

Advanced: Studs framed on 24 inch centers with double top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and one stud is used to support each header. Headers consist of double 2x material with R-10 insulation between the header and exterior sheathing. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Advanced Framing Weighting Factors:

Studs and plates	0.13
Insulated cavity	0.83
Headers	0.04

1005.3 Component Description: Default coefficients for the following types of walls are listed: single-stud walls, strap walls, double-stud walls, log walls, stress-skin panels, metal stud walls, and metal building walls.

Single-Stud Wall, Tables 10-5(1) through 10-5(8)**:** Assumes either 2x4 or 2x6 studs framed on 16 or 24 inch centers. Headers are solid for 2x4 walls and double 2x for 2x6 walls, with either dead-air or rigid-board insulation in the remaining space.

Strap Wall, Table 10-5(9)**:** Assumes 2x6 studs framed on 16 or 24 inch centers. 2x3 or 2x4 strapping is run horizontally along the interior surface of the wall to provide additional space for insulation.

Double-Stud Wall, Tables 10-5(10) and 10-5(11)**:** Assumes an exterior structural wall and a separate interior, non-structural wall. Insulation is placed in both wall cavities and in the space between the two walls. Stud spacing is assumed to be on 24 inch centers for both walls.

Log Wall, Table 10-5(12).

Stress-Skin Panel, Table 10-5(13).

Metal Stud Wall, Overall Assembly U-Factors, Table 10-5A(1)**:** Assumes metal studs spaced on 16 or 24 inch centers with insulation installed to fill wall cavities. Continuous rigid board insulation is applied without creating uninsulated voids in the wall assembly.

Metal Stud Wall, Effective R-Values for Metal Framing and Cavity Only, Table 10-5A(2): These values may be used for the metal-framing/cavity layers in walls with metal studs spaced on 16- or 24-inch centers with insulation installed to fill wall cavities in lieu of using the zone method provided in Chapter 25 of Standard RS-1 listed in Chapter 7.

Metal Building Wall, Table 10-5A(3): A wall whose structure consists of metal spanning panels supported by steel structural members (does not include spandrel glass or metal panels in curtain wall systems). The first nominal R-value is for insulation compressed between metal wall panels and the steel structure. For double-layer installations, the second rated R-value of insulation is for insulation installed from the inside, covering the girts. For continuous insulation (e.g., insulation boards) it is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semiheated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

Concrete and Masonry Walls, Table 10-5B(1).

Peripheral Edges of Intermediate Concrete Floors, Table 10-5B(2).

TABLE 10-5
DEFAULT U-FACTORS FOR ABOVE-GRADE WALLS

TABLE 10-5(1)
2 x 4 Single Wood Stud: R-11 Batt

NOTE:

Nominal Batt R-value:
R-11 at 3.5 inch thickness

Installed Batt R-value:
R-11 in 3.5 inch cavity

Siding Material/Framing Type				
	Lapped Wood		T1-11	
R-value of Foam Board	STD	ADV	STD	ADV
0	0.088	0.084	0.094	0.090
1	0.080	0.077	0.085	0.082
2	0.074	0.071	0.078	0.075
3	0.069	0.066	0.072	0.070
4	0.064	0.062	0.067	0.065
5	0.060	0.058	0.063	0.061
6	0.056	0.055	0.059	0.057
7	0.053	0.052	0.055	0.054
8	0.051	0.049	0.052	0.051
9	0.048	0.047	0.050	0.049
10	0.046	0.045	0.047	0.046
11	0.044	0.043	0.045	0.044
12	0.042	0.041	0.043	0.042

TABLE 10-5(2)
2 x 4 Single Wood Stud: R-13 Batt

NOTE:

Nominal Batt R-value:
R-13 at 3.63 inch thickness

Installed Batt R-value:
R-12.7 in 3.5 inch cavity

Siding Material/Framing Type				
	Lapped Wood		T1-11	
R-value of Foam Board	STD	ADV	STD	ADV
0	0.082	0.078	0.088	0.083
1	0.075	0.072	0.080	0.076
2	0.069	0.066	0.073	0.070
3	0.065	0.062	0.068	0.065
4	0.060	0.058	0.063	0.061
5	0.057	0.055	0.059	0.057
6	0.053	0.052	0.056	0.054
7	0.051	0.049	0.052	0.051
8	0.048	0.047	0.050	0.048
9	0.046	0.045	0.047	0.046
10	0.044	0.043	0.045	0.044
11	0.042	0.041	0.043	0.042
12	0.040	0.039	0.041	0.040

TABLE 10-5(3)
2 x 4 Single Wood Stud: R-15 Batt

NOTE:
Nominal Batt R-value:
R-15 at 3.5 inch thickness

Installed Batt R-value:
R-15 in 3.5 inch cavity

Siding Material/Framing Type				
	Lapped Wood		T1-11	
R-value of Foam Board	STD	ADV	STD	ADV
0	0.076	0.071	0.081	0.075
1	0.069	0.065	0.073	0.069
2	0.064	0.061	0.068	0.069
3	0.060	0.057	0.063	0.059
4	0.056	0.053	0.059	0.056
5	0.053	0.051	0.055	0.052
6	0.050	0.048	0.052	0.050
7	0.047	0.046	0.049	0.047
8	0.045	0.044	0.047	0.045
9	0.043	0.042	0.044	0.043
10	0.041	0.040	0.042	0.041
11	0.039	0.038	0.041	0.039
12	0.038	0.037	0.039	0.038

TABLE 10-5(4)
2 x 6 Single Wood Stud: R-19 Batt

NOTE:
Nominal Batt R-value:
R-19 at 6 inch thickness

Installed Batt R-value:
R-18 in 5.5 inch cavity

Siding Material/Framing Type						
	Lapped Wood			T1-11		
R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
0	0.062	0.058	0.055	0.065	0.061	0.058
1	0.058	0.055	0.052	0.060	0.057	0.055
2	0.054	0.052	0.050	0.056	0.054	0.051
3	0.051	0.049	0.047	0.053	0.051	0.049
4	0.048	0.046	0.045	0.050	0.048	0.046
5	0.046	0.044	0.043	0.048	0.046	0.044
6	0.044	0.042	0.041	0.045	0.044	0.042
7	0.042	0.040	0.039	0.043	0.042	0.040
8	0.040	0.039	0.038	0.041	0.040	0.039
9	0.038	0.037	0.035	0.039	0.038	0.037
10	0.037	0.036	0.035	0.038	0.037	0.036
11	0.036	0.035	0.034	0.036	0.035	0.035
12	0.034	0.033	0.033	0.035	0.034	0.033

TABLE 10-5(5)
2 x 6 Single Wood Stud: R-21 Batt

NOTE:
Nominal Batt R-value:
R-21 at 5.5 inch thickness

Installed Batt R-value:
R-21 in 5.5 inch cavity

Siding Material/Framing Type						
	Lapped Wood			T1-11		
R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
0	0.057	0.054	0.051	0.060	0.056	0.053
1	0.054	0.051	0.048	0.056	0.053	0.050
2	0.050	0.048	0.045	0.052	0.050	0.047
3	0.048	0.045	0.043	0.049	0.047	0.045
4	0.045	0.043	0.041	0.047	0.045	0.043
5	0.043	0.041	0.040	0.044	0.042	0.041
6	0.041	0.039	0.038	0.042	0.041	0.039
7	0.039	0.038	0.036	0.040	0.039	0.037
8	0.038	0.036	0.035	0.039	0.037	0.036
9	0.036	0.035	0.034	0.037	0.036	0.035
10	0.035	0.034	0.033	0.036	0.035	0.033
11	0.033	0.033	0.032	0.034	0.033	0.032
12	0.032	0.031	0.031	0.033	0.032	0.031

TABLE 10-5(6)
2 x 6 Single Wood Stud: R-22 Batt

NOTE:
Nominal Batt R-value:
R-22 at 6.75 inch thickness

Installed Batt R-value:
R-20 in 5.5 inch cavity

Siding Material/Framing Type						
	Lapped Wood			T1-11		
R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
0	0.059	0.055	0.052	0.062	0.058	0.054
1	0.055	0.052	0.049	0.057	0.054	0.051
2	0.052	0.049	0.047	0.054	0.051	0.048
3	0.049	0.046	0.044	0.050	0.048	0.046
4	0.046	0.044	0.042	0.048	0.046	0.044
5	0.044	0.042	0.041	0.045	0.043	0.042
6	0.042	0.040	0.039	0.043	0.042	0.040
7	0.040	0.039	0.037	0.041	0.040	0.038
8	0.038	0.037	0.036	0.039	0.038	0.037
9	0.037	0.036	0.035	0.038	0.037	0.035
10	0.035	0.034	0.033	0.036	0.035	0.034
11	0.034	0.033	0.032	0.035	0.034	0.033
12	0.033	0.032	0.031	0.034	0.033	0.032

TABLE 10-5(7)
2 x 6 Single Wood Stud: Two R-11 Batts

NOTE:
Nominal Batt R-value:
R-22 at 7 inch thickness

Installed Batt R-value:
R-18.9 in 5.5 inch cavity

Siding Material/Framing Type						
	Lapped Wood			T1-11		
R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
0	0.060	0.057	0.054	0.063	0.059	0.056
1	0.056	0.053	0.051	0.059	0.056	0.053
2	0.053	0.050	0.048	0.055	0.052	0.050
3	0.050	0.048	0.046	0.052	0.049	0.047
4	0.047	0.045	0.044	0.049	0.047	0.045
5	0.045	0.043	0.042	0.046	0.045	0.043
6	0.043	0.041	0.040	0.044	0.043	0.041
7	0.041	0.040	0.038	0.042	0.041	0.039
8	0.039	0.038	0.037	0.040	0.039	0.038
9	0.038	0.037	0.036	0.039	0.038	0.036
10	0.036	0.035	0.034	0.037	0.036	0.035
11	0.035	0.034	0.033	0.036	0.035	0.034
12	0.034	0.033	0.032	0.034	0.034	0.033

TABLE 10-5(8)
2 x 8 Single Stud: R-25 Batt

NOTE:
Nominal Batt R-value:
R-25 at 8 inch thickness

Installed Batt R-value:
R-23.6 in 7.25 inch cavity

Siding Material/Framing Type						
	Lapped Wood			T1-11		
R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
0	0.051	0.047	0.045	0.053	0.049	0.046
1	0.048	0.045	0.043	0.049	0.046	0.044
2	0.045	0.043	0.041	0.047	0.044	0.042
3	0.043	0.041	0.039	0.044	0.042	0.040
4	0.041	0.039	0.037	0.042	0.040	0.038
5	0.039	0.037	0.036	0.040	0.038	0.037
6	0.037	0.036	0.035	0.038	0.037	0.036
7	0.036	0.035	0.033	0.037	0.035	0.034
8	0.035	0.033	0.032	0.035	0.034	0.033
9	0.033	0.032	0.031	0.034	0.033	0.032
10	0.032	0.031	0.030	0.033	0.032	0.031
11	0.031	0.030	0.029	0.032	0.031	0.030
12	0.030	0.029	0.028	0.031	0.030	0.029

TABLE 10-5(9)
2 x 6: Strap Wall

	Siding Material/Frame Type			
	Lapped Wood		T1-11	
	STD	ADV	STD	ADV
R-19 + R-11 Batts	0.036	0.035	0.038	0.036
R-19 + R-8 Batts	0.041	0.039	0.042	0.040

TABLE 10-5(10)
2 x 6 ÷ 2 x 4: Double Wood Stud

Batt Configuration			Siding Material/Frame Type			
			Lapped Wood		T1-11	
Exterior	Middle	Interior	STD	ADV	STD	ADV
R-19	--	R-11	0.040	0.037	0.041	0.038
R-19	--	R-19	0.034	0.031	0.035	0.032
R-19	R-8	R-11	0.029	0.028	0.031	0.029
R-19	R-11	R-11	0.027	0.026	0.028	0.027
R-19	R-11	R-19	0.024	0.023	0.025	0.023
R-19	R-19	R-19	0.021	0.020	0.021	0.020

TABLE 10-5(11)
2 x 4 ÷ 2 x 4: Double Wood Stud

Batt Configuration			Siding Material/Frame Type			
			Lapped Wood		T1-11	
Exterior	Middle	Interior	STD	ADV	STD	ADV
R-11	--	R-11	0.050	0.046	0.052	0.048
R-19	--	R-11	0.039	0.037	0.043	0.039
R-11	R-8	R-11	0.037	0.035	0.036	0.036
R-11	R-11	R-11	0.032	0.031	0.033	0.032
R-13	R-13	R-13	0.029	0.028	0.029	0.028
R-11	R-19	R-11	0.026	0.026	0.027	0.026

TABLE 10-5(12)
Log Walls

NOTE:
R-value of wood:
R-1.25 per inch thickness

Average wall thickness
90% average log diameter

Average Log Diameter, Inches	U-factor
6	0.148
8	0.111
10	0.089
12	0.074
14	0.063
16	0.056

TABLE 10-5(13)
Stress Skin Panel

NOTE:
R-value of expanded
polystyrene: R-3.85 per inch

Framing: 6%
Spline: 8%
No thermal bridging between interior and exterior splines

Panel Thickness, Inches	U-factor
3 1/2	0.071
5 1/2	0.048
7 1/4	0.037
9 1/4	0.030
11 1/4	0.025

Metal Stud Walls: The nominal R-values in Table 10-5A may be used for purposes of calculating metal stud wall section U-factors in lieu of the ASHRAE zone calculation method as provided in Chapter 27 of Standard RS-1.

TABLE 10-5A
DEFAULT U-FACTORS FOR OVERALL ASSEMBLY METAL STUD WALLS, EFFECTIVE R-VALUES FOR METAL FRAMING AND CAVITY ONLY, AND DEFAULT METAL BUILDING U-FACTORS

TABLE 10-5A(1)
OVERALL ASSEMBLY U-FACTORS FOR METAL STUD WALLS

Metal Framing	R-Value of Continuous Foam Board Insulation	Cavity Insulation					
		R-0	R-11	R-13	R-15	R-19	R-21
16" o.c.	R-0 (none)	0.352	0.132	0.124	0.118	0.109	0.106
	R-1	0.260	0.117	0.111	0.106	0.099	0.096
	R-2	0.207	0.105	0.100	0.096	0.090	0.087
	R-3	0.171	0.095	0.091	0.087	0.082	0.080
	R-4	0.146	0.087	0.083	0.080	0.076	0.074
	R-5	0.128	0.080	0.077	0.074	0.071	0.069
	R-6	0.113	0.074	0.071	0.069	0.066	0.065
	R-7	0.102	0.069	0.066	0.065	0.062	0.061
	R-8	0.092	0.064	0.062	0.061	0.058	0.057
	R-9	0.084	0.060	0.059	0.057	0.055	0.054
	R-10	0.078	0.057	0.055	0.054	0.052	0.051
	R-11	0.072	0.054	0.052	0.051	0.050	0.049
	R-12	0.067	0.051	0.050	0.049	0.047	0.047
	R-13	0.063	0.049	0.048	0.047	0.045	0.045
	R-14	0.059	0.046	0.045	0.045	0.043	0.043
	R-15	0.056	0.044	0.043	0.043	0.041	0.041
	R-20	0.044	0.036	0.036	0.035	0.034	0.034
24" o.c	R-0 (none)	0.338	0.116	0.108	0.102	0.094	0.090
	R-1	0.253	0.104	0.098	0.092	0.086	0.083
	R-2	0.202	0.094	0.089	0.084	0.079	0.077
	R-3	0.168	0.086	0.082	0.078	0.073	0.071
	R-4	0.144	0.079	0.075	0.072	0.068	0.066
	R-5	0.126	0.073	0.070	0.067	0.064	0.062
	R-6	0.112	0.068	0.066	0.063	0.060	0.059
	R-7	0.100	0.064	0.062	0.059	0.057	0.055
	R-8	0.091	0.060	0.058	0.056	0.054	0.052
	R-9	0.084	0.057	0.055	0.053	0.051	0.050
	R-10	0.077	0.054	0.052	0.050	0.048	0.048
	R-11	0.072	0.051	0.049	0.048	0.046	0.045
	R-12	0.067	0.048	0.047	0.046	0.044	0.043
	R-13	0.063	0.046	0.045	0.044	0.042	0.042
	R-14	0.059	0.044	0.043	0.042	0.041	0.040
	R-15	0.056	0.042	0.041	0.040	0.039	0.038
	R-20	0.044	0.035	0.034	0.034	0.033	0.032

FOOTNOTE:
Continuous foam board insulation: Continuous insulation assumes no thermal bridging of insulation by framing or z-furring through applied foam board. Zone calculation method as provided in RS-1 must be used for thermally bridged foam board insulation.

TABLE 10-5A(2)
EFFECTIVE R-VALUES FOR METAL FRAMING AND CAVITY ONLY

	Cavity		Insulation		
	Nominal Depth, Inches	Actual Depth, Inches	Nominal R-Value	Effective R-Value 16" O.C.	Effective R-Value 24" O.C.
Air Cavity	Any	Any	R-0.91 (air)	0.79	0.91
Wall	4	3-1/2	R-11	5.5	6.6
	4	3-1/2	R-13	6.0	7.2
	4	3-1/2	R-15	6.4	7.8
	6	5-1/2	R-19	7.1	8.6
	6	5-1/2	R-21	7.4	9.0
	8	7-1/4	R-25	7.8	9.6
Roof		Insulation is uncompressed	R-11	5.5	6.1
			R-19	7.0	9.1
			R-30	9.3	11.4

TABLE 10-5A(3)
DEFAULT METAL BUILDING WALL U-FACTORS

Insulation System	Rated R-Value of Insulation	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing)					
			R-6.5	R-13	R-19.5	R-26	R-32.5	R-39
Single Layer of Mineral Fiber								
	None	1.180	0.136	0.072	0.049	0.037	0.030	0.025
	R-10	0.186	0.084	0.054	0.040	0.032	0.026	0.023
	R-11	0.185	0.084	0.054	0.040	0.032	0.026	0.023
	R-13	0.162	0.079	0.052	0.039	0.031	0.026	0.022
	R-16	0.155	0.077	0.051	0.039	0.031	0.026	0.022
	R-19	0.147	0.075	0.050	0.038	0.030	0.025	0.022

Concrete Masonry Walls: The nominal R-values in Table 10-5B may be used for purposes of calculating concrete masonry wall section U-factors in lieu of the ASHRAE isothermal planes calculation method as provided in Chapter 27 of Standard RS-1.

TABLE 10-5B(1)
DEFAULT U-FACTORS FOR CONCRETE AND MASONRY WALLS

8" Concrete Masonry

WALL DESCRIPTION	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			Solid Grout
	Empty	Loose-fill Insulated		
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.40	0.23	0.24	0.43
R-5 Interior Insulation, Wood Furring	0.14	0.11	0.12	0.15
R-6 Interior Insulation, Wood Furring	0.14	0.11	0.11	0.14
R-10.5 Interior Insulation, Wood Furring	0.11	0.09	0.09	0.11
R-8 Interior Insulation, Metal Clips	0.11	0.09	0.09	0.11
R-6 Exterior Insulation	0.12	0.10	0.10	0.12
R-10 Exterior Insulation	0.08	0.07	0.07	0.08
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	0.11	0.09	0.09	0.12

12" Concrete Masonry

WALL DESCRIPTION	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			Solid Grout
	Empty	Loose-fill insulated		
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.35	0.17	0.18	0.33
R-5 Interior Insulation, Wood Furring	0.14	0.10	0.10	0.13
R-6 Interior Insulation, Wood Furring	0.13	0.09	0.10	0.13
R-10.5 Interior Insulation, Wood Furring	0.11	0.08	0.08	0.10
R-8 Interior Insulation, Metal Clips	0.10	0.08	0.08	0.09
R-6 Exterior Insulation	0.11	0.09	0.09	0.11
R-10 Exterior Insulation	0.08	0.06	0.06	0.08
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	0.11	0.08	0.09	0.12

8" Clay Brick

WALL DESCRIPTION	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			Solid Grout
	Empty	Loose-fill insulated		
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.50	0.31	0.32	0.56
R-5 Interior Insulation, Wood Furring	0.15	0.13	0.13	0.16
R-6 Interior Insulation, Wood Furring	0.15	0.12	0.12	0.15
R-10.5 Interior Insulation, Wood Furring	0.12	0.10	0.10	0.12
R-8 Interior Insulation, Metal Clips	0.11	0.10	0.10	0.11
R-6 Exterior Insulation	0.12	0.11	0.11	0.13
R-10 Exterior Insulation	0.08	0.08	0.08	0.09

6" Concrete Poured or Precast

WALL DESCRIPTION	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			Solid Grout
	Empty	Loose-fill insulated		
		Perlite	Vermiculite	
Exposed Concrete, Both Sides	NA	NA	NA	0.61
R-5 Interior Insulation, Wood Furring	NA	NA	NA	0.16
R-6 Interior Insulation, Wood Furring	NA	NA	NA	0.15
R-10.5 Interior Insulation, Wood Furring	NA	NA	NA	0.12
R-8 Interior Insulation, Metal Clips	NA	NA	NA	0.12
R-6 Exterior Insulation	NA	NA	NA	0.13
R-10 Exterior Insulation	NA	NA	NA	0.09

Notes for Default Table 10-5B(1) 1. Grouted cores at 40" x 48" on center vertically and horizontally in partial grouted walls.
2. Interior insulation values include 1/2" gypsum board on the inner surface.
3. Furring and stud spacing is 16" on center. Insulation is assumed to fill furring space and is not compressed.
4. Intermediate values may be interpolated using this table. Values not contained in this table may be computed using the procedures listed in Standard RS-1.

TABLE 10-5B(2)
PERIPHERAL EDGES OF INTERMEDIATE CONCRETE FLOORS

Slab Edge Treatment	Average Thickness of Wall Above and Below			
	6 inches	8 inches	10 inches	12 inches
Exposed Concrete	0.816	0.741	0.678	0.625
R-5 Exterior Insulation	0.161	0.157	0.154	0.152
R-6 Exterior Insulation	0.138	0.136	0.134	0.132
R-7 Exterior Insulation	0.122	0.120	0.118	0.116
R-8 Exterior Insulation	0.108	0.107	0.106	0.104
R-9 Exterior Insulation	0.098	0.097	0.095	0.094
R-10 Exterior Insulation	0.089	0.088	0.087	0.086
R-11 Exterior Insulation	0.082	0.081	0.080	0.079
R-12 Exterior Insulation	0.076	0.075	0.074	0.074
R-13 Exterior Insulation	0.070	0.070	0.069	0.068
R-14 Exterior Insulation	0.066	0.065	0.065	0.064
R-15 Exterior Insulation	0.062	0.061	0.061	0.060

SECTION 1006 — DEFAULT U-FACTORS FOR GLAZING AND DOORS

1006.1 Glazing and Doors Without NFRC Certification: Glazing and doors that do not have NFRC Certification shall be assigned the following U-factors.

TABLE 10-6
OTHER THAN SINGLE-FAMILY RESIDENTIAL:
DEFAULT U-FACTORS FOR VERTICAL GLAZING, OVERHEAD GLAZING AND OPAQUE DOORS

VERTICAL GLAZING

	U-Factor		
	Any Frame	Aluminum w/Thermal Break	Wood/ Vinyl/ Fiberglass Frame
Single	1.45	1.45	1.45
Double	0.90	0.85	0.75
1/2 Inch Air, Fixed/Operable	0.75/0.90	0.70/0.84	0.60/0.72
1/2 Inch Air, Low-e$^{(0.40)}$, Fixed/Operable	0.70/0.84	0.60/0.72	0.50/0.60
1/2 Inch Air, Low-e$^{(0.10)}$, Fixed/Operable	0.65/0.78	0.44/0.66	0.45/0.54
1/2 Inch Argon, Low-e$^{(0.10)}$, Fixed/Operable	0.60/0.72	0.50/0.60	0.40/0.48
Triple	0.75	0.55	0.50
1/2 Inch Air, Fixed/Operable	0.55/0.66	0.50/0.60	0.45/0.54
1/2 Inch Air, Low-e$^{(0.20)}$, Fixed/Operable	0.50/0.60	0.45/0.54	0.40/0.48
1/2 Inch Air, 2 Low-e$^{(0.10)}$, Fixed/Operable	0.45/0.54	0.35/0.42	0.30/0.36
1/2 Inch Argon, Low-e$^{(0.10)}$, Fixed/Operable	0.40/0.48	0.30/0.36	0.25/0.30

The category for aluminum frame with a thermal break is as defined in footnote 7 to Table 10-6A.

OVERHEAD GLAZING: SLOPED GLAZING (INCLUDING FRAME)

	U-Factor		
	Any Frame	Aluminum w/Thermal Break	Wood/Vinyl/ Fiberglass Frame
Single	1.74	1.74	1.74
Double	1.08	1.02	0.90
1/2 Inch Air, Fixed	0.90	0.84	0.72
1/2 Inch Air, Low-$e^{(0.40)}$, Fixed	0.84	0.72	0.60
1/2 Inch Air, Low-$e^{(0.10)}$, Fixed	0.78	0.66	0.54
1/2 Inch Argon, Low-$e^{(0.10)}$, Fixed	0.72	0.60	0.48
Triple	0.90	0.66	0.60
1/2 Inch Air, Fixed	0.66	0.60	0.54
1/2 Inch Air, Low-$e^{(0.20)}$, Fixed	0.60	0.54	0.48
1/2 Inch Air, 2 Low-$e^{(0.10)}$, Fixed	0.54	0.42	0.36
1/2 Inch Argon, 2Low-$e^{(0.10)}$, Fixed	0.48	0.36	0.30

This default table is applicable to sloped glazing only. (Sloped glazing is a multiple-lite glazed system [similar to a curtain wall] that is mounted at a slope greater than 15° from the vertical plane.) Other overhead glazing shall use the defaults in Table 10-6E.

OPAQUE DOORS

	U-Factor
Uninsulated Metal	1.20
Insulated Metal (Including Fire Door and Smoke Vent)	0.60
Wood	0.50
Other Doors	See Table 10-6C

NOTES:

Where a gap width is listed (i.e.: 1/2 inch), that is the minimum allowed.

Where a low-emissivity emittance is listed (i.e.: 0.40, 0.20, 0.10), that is the maximum allowed.

Where a gas other than air is listed (i.e.: Argon), the gas fill shall be a minimum of 90%.

Where an operator type is listed (i.e.: Fixed), the default is only allowed for that operator type.

Where a frame type is listed (i.e.: Wood/Vinyl), the default is only allowed for that frame type. Wood/Vinyl frame includes reinforced vinyl and aluminum-clad wood.

TABLE 10-6A
GROUP R OCCUPANCY:
DEFAULT U-FACTORS FOR VERTICAL GLAZING

Description[1,2,3,4]			Frame Type[5,6]		
			Aluminum	Aluminum Thermal Break[7]	Wood / Vinyl
Windows	Single		1.20	1.20	1.20
	Double, < 1/2"	Clear	0.92	0.75	0.63
		Clear + Argon	0.87	0.71	0.60
		Low-e	0.85	0.69	0.58
		Low-e + Argon	0.79	0.62	0.53
	Double, ≥ 1/2"	Clear	0.86	0.69	0.58
		Clear + Argon	0.83	0.67	0.55
		Low-e	0.78	0.61	0.51
		Low-e + Argon	0.75	0.58	0.48
	Triple,	Clear	0.70	0.53	0.43
		Clear + Argon	0.69	0.52	0.41
		Low-e	0.67	0.49	0.40
		Low-e + Argon	0.63	0.47	0.37
Garden Windows	Single		2.60	n.a.	2.31
	Double	Clear	1.81	n.a.	1.61
		Clear + Argon	1.76	n.a.	1.56
		Low-e	1.73	n.a.	1.54
		Low-e + Argon	1.64	n.a.	1.47

1. <1/2" = a minimum dead air space of less than 0.5 inches between the panes of glass.
   ≥1/2" = a minimum dead air space of 0.5 inches or greater between the panes of glass.
   Where no gap width is listed, the minimum gap width is 1/4".
2. Any low-e (emissivity) coating (0.1, 0.2 or 0.4).
3. U-factors listed for argon shall consist of sealed, gas-filled insulated units for argon, CO_2, SF_6, argon/SF_6 mixtures and Krypton.
4. "Glass block" assemblies may use a U-factor of 0.51.
5. Insulated fiberglass framed products shall use wood/vinyl U-factors.
6. Aluminum clad wood windows shall use the U-factors listed for wood/vinyl windows.
7. Aluminum Thermal Break = An aluminum thermal break framed window shall incorporate the following minimum design characteristics:
   a) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/ft^2/°F;
   b) The thermal break material must produce a gap in the frame material of not less than 0.210 inches; and,
   c) All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in a) and b) above.

TABLE 10-6B
ALL OCCUPANCIES:
SMALL BUSINESS COMPLIANCE TABLE
DEFAULT U-FACTORS FOR VERTICAL GLAZING

Vertical Glazing Description				Frame Type		
Panes	Low-e[1]	Spacer	Fill	Any Frame	Aluminum Thermal Break[2]	Wood/Vinyl/ Fiberglass
Double[3]	A	Any	Argon	0.48	0.41	0.32
	B	Any	Argon	0.46	0.39	0.30
	C	Any	Argon	0.44	0.37	0.28
	C	High Performance	Argon	0.42	0.35	Deemed to comply[5]
Triple[4]	A	Any	Air	0.50	0.44	0.26
	B	Any	Air	0.45	0.39	0.22
	C	Any	Air	0.41	0.34	0.20
	Any double low-e	Any	Air	0.35	0.32	0.18

FOOTNOTES TO TABLE 10-6B

1. Low-eA (emissivity) shall be 0.24 to 0.16.
   Low-eB (emissivity) shall be 0.15 to 0.08.
   Low-eC (emissivity) shall be 0.07 or less.
2. Aluminum Thermal Break = An aluminum thermal break framed window shall incorporate the following minimum design characteristics:
   a) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/ft^2/°F;
   b) The thermal break material must produce a gap in the frame material of not less than 0.210 inches; and
   c) All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in a and b above.
3. A minimum air space of 0.375 inches between panes of glass is required for double glazing.
4. A minimum air space of 0.25 inches between panes of glass is required for triple glazing.
5. Deemed to comply glazing shall not be used for performance compliance.

TABLE 10-6C
GROUP R OCCUPANCY:
DEFAULT U-FACTORS FOR DOORS

Door Type	No Glazing	Single Glazing	Double Glazing with ¼ in. Airspace	Double Glazing with ½ in. Airspace	Double Glazing with e=0.10, ½ in. Argon
SWINGING DOORS (Rough opening – 38 in. x 82 in.)					
Slab Doors					
Wood slab in wood frame[a]	0.46				
6% glazing (22 in. x 8 in. lite)	–	0.48	0.47	0.46	0.44
25% glazing (22 in. x 36 in. lite)	–	0.58	0.48	0.46	0.42
45% glazing (22 in. x 64 in. lite)	–	0.69	0.49	0.46	0.39
More than 50% glazing	Use Table 10-6A				
Insulated steel slab with wood edge in wood frame[a]	0.16				
6% glazing (22 in. x 8 in. lite)	–	0.21	0.20	0.19	0.18
25% glazing (22 in. x 36 in. lite)	–	0.39	0.28	0.26	0.23
45% glazing (22 in. x 64 in. lite)	–	0.58	0.38	0.35	0.26
More than 50% glazing	Use Table 10-6A				
Foam insulated steel slab with metal edge in steel frame[b]	0.37				
6% glazing (22 in. x 8 in. lite)	–	0.44	0.42	0.41	0.39
25% glazing (22 in. x 36 in. lite)	–	0.55	0.50	0.48	0.44
45% glazing (22 in. x 64 in. lite)	–	0.71	0.59	0.56	0.48
More than 50% glazing	Use Table 10-6A				
Cardboard honeycomb slab with metal edge in steel frame[b]	0.61				
Style and Rail Doors					
Sliding glass doors/French doors	Use Table 10-6A				
Site-Assembled Style and Rail Doors					
Aluminum in aluminum frame	–	1.32	0.99	0.93	0.79
Aluminum in aluminum frame with thermal break	–	1.13	0.80	0.74	0.63

a. Thermally broken sill (add 0.03 for non-thermally broken sill)
b. Non-thermally broken sill
c. Nominal U-factors are through the center of the insulated panel before consideration of thermal bridges around the edges of the door section and due to the frame.

Revolving Doors	
Size (W x H)	**U-Factor**
3-wing	
8 ft x 7 ft	0.79
10 ft x 8 ft	0.80
4-wing	
7 ft x 6.5 ft	0.63
7 ft x 7.5 ft	0.64
Open	
82 in x 84 in	1.32

Double-Skin Steel Emergency Exit Doors		
Core Insulation	**3 ft x 6 ft 8 in**	**6 ft x 6 ft 8 in**
1-3/8 in. thickness		
Honeycomb kraft paper	0.57	0.52
Mineral wool, steel ribs	0.44	0.36
Polyurethane foam	0.34	0.28
1-3/4 in. thickness		
Honeycomb kraft paper	0.57	0.54
Mineral wool, steel ribs	0.41	0.33
Polyurethane foam	0.31	0.26
1-3/8 in. thickness		
Honeycomb kraft paper	0.60	0.55
Mineral wool, steel ribs	0.47	0.39
Polyurethane foam	0.37	0.31
1-3/4 in. thickness		
Honeycomb kraft paper	0.60	0.57
Mineral wool, steel ribs	0.44	0.37
Polyurethane foam	0.34	0.30

Double-Skin Steel Garage and Aircraft Hangar Doors					
Insulation[e]	One-piece tilt-up[a]		Sectional tilt-up[b]	Aircraft hangar	
	8 ft. x 7 ft.	16 ft. x 7 ft.	9 ft. x 7 ft.	72 ft. x 12 ft.[c]	240 ft. x 50 ft.[d]
1-3/8 in. thickness					
EPS, steel ribs	0.36	0.33	0.34-0.39		
XPS, steel ribs	0.33	0.31	0.31-0.36		
2 in. thickness					
EPS, steel ribs	0.31	0.28	0.29-0.33		
XPS, steel ribs	0.29	0.26	0.27-0.31		
3 in. thickness					
EPS, steel ribs	0.26	0.23	0.25-0.28		
XPS, steel ribs	0.24	0.21	0.24-0.27		
4 in. thickness					
EPS, steel ribs	0.23	0.20	0.23-0.25		
XPS, steel ribs	0.21	0.19	0.21-0.24		
6 in. thickness					
EPS, steel ribs	0.20	0.16	0.20-0.21		
XPS, steel ribs	0.19	0.15	0.19-0.21		
4 in. thickness					
Non-insulated				1.10	1.23
Expanded polystyrene				0.25	0.16
Mineral wool, steel ribs				0.25	0.16
Extruded polystyrene				0.23	0.15
6 in. thickness					
Non-insulated				1.10	1.23
Expanded polystyrene				0.21	0.13
Mineral wool, steel ribs				0.23	0.13
Extruded polystyrene				0.20	0.12
Uninsulated					
All products	1.15				

a. Values are for thermally broken or thermally unbroken doors.
b. Lower values are for thermally broken doors; upper values are for doors with no thermal break.
c. Typical size for a small private airplane (single-engine or twin).
d. Typical hangar door for a midsize commercial jet airliner.
e. EPS is extruded polystyrene, XPS is expanded polystyrene.

TABLE 10-6D
GROUP R OCCUPANCY: DEFAULT U-FACTORS FOR GLAZED DOORS
(SEE TABLE 10-6C)

TABLE 10-6E
GROUP R OCCUPANCY:
DEFAULT U-FACTORS FOR OVERHEAD GLAZING

Glazing Type	Frame Type			
	Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum-Clad Wood or Vinyl	Wood or Vinyl-Clad Wood/ Vinyl without Reinforcing
Single Glazing				
glass	U-1.58	U-1.51	U-1.40	U-1.18
acrylic/polycarb	U-1.52	U-1.45	U-1.34	U-1.11
Double Glazing				
air	U-1.05	U-0.89	U-0.84	U-0.67
argon	U-1.02	U-0.86	U-0.80	U-0.64
Double Glazing, *e*=0.20				
air	U-0.96	U-0.80	U-0.75	U-0.59
argon	U-0.91	U-0.75	U-0.70	U-0.54
Double Glazing, *e*=0.10				
air	U-0.94	U-0.79	U-0.74	U-0.58
argon	U-0.89	U-0.73	U-0.68	U-0.52
Double Glazing, *e*=0.05				
air	U-0.93	U-0.78	U-0.73	U-0.56
argon	U-0.87	U-0.71	U-0.66	U-0.50
Triple Glazing				
air	U-0.90	U-0.70	U-0.67	U-0.51
argon	U-0.87	U-0.69	U-0.64	U-0.48
Triple Glazing, *e*=0.20				
air	U-0.86	U-0.68	U-0.63	U-0.47
argon	U-0.82	U-0.63	U-0.59	U-0.43
Triple Glazing, *e*=0.20 on 2 surfaces				
air	U-0.82	U-0.64	U-0.60	U-0.44
argon	U-0.79	U-0.60	U-0.56	U-0.40
Triple Glazing, *e*=0.10 on 2 surfaces				
air	U-0.81	U-0.62	U-0.58	U-0.42
argon	U-0.77	U-0.58	U-0.54	U-0.38
Quadruple Glazing, *e*=0.10 on 2 surfaces				
air	U-0.78	U-0.59	U-0.55	U-0.39
argon	U-0.74	U-0.56	U-0.52	U-0.36
krypton	U-0.70	U-0.52	U-0.48	U-0.32

1. U-factors are applicable to both glass and plastic, flat and domed units, all spacers and gaps.
2. Emissivities shall be less than or equal to the value specified.
3. Gap fill shall be assumed to be air unless there is a minimum of 90% argon or krypton.
4. Aluminum frame with thermal break is as defined in footnote 2 to Table 10-6B.

SECTION 1007 -- CEILINGS

1007.1 General: Table 10-7 lists heat loss coefficients for the opaque portion of exterior ceilings below vented attics, vaulted ceilings and roof decks in units of Btu/h•ft²•°F of ceiling.

They are derived from procedures listed in Standard RS-1, listed in Chapter 7. Ceiling U-factors are modified for the buffering effect of the attic, assuming an indoor temperature of 65°F and an outdoor temperature of 45°F.

Metal Framed Ceilings: The nominal R-values in Table 10-5A(2): Effective R-Values for Metal Framing and Cavity Only may be used for purposes of calculating metal framed ceiling section U-factors in lieu of the ASHRAE zone calculation method as provided in Chapter 27 of Standard RS-1.

Metal building roofs have a different construction and are addressed in Table 10-7F.

1007.2 Component Description: The four types of ceilings are characterized as follows:

Ceilings Below a Vented Attic: Attic insulation is assumed to be blown-in, loose-fill fiberglass with a K-value of 2.6 h•ft²•°F/Btu per inch. Full bag count for specified R-value is assumed in all cases. Ceiling dimensions for flat ceiling calculations are 45 by 30 feet, with a gabled roof having a 4/12 pitch. The attic is assumed to vent naturally at the rate of 3 air changes per hour through soffit and ridge vents. A void fraction of 0.002 is assumed for all attics with insulation baffles. Standard-framed, unbaffled attics assume a void fraction of 0.008.

Attic framing is either standard or advanced. Standard framing assumes tapering of insulation depth around the perimeter with resultant decrease in thermal resistance. An increased R-value is assumed in the center of the ceiling due to the effect of piling leftover insulation. Advanced framing assumes full and even depth of insulation extending to the outside edge of exterior walls. Advanced framing does not change from the default value.

U-factors for flat ceilings below vented attics with standard framing may be modified with the following table:

Roof Pitch	U-factor for Standard Framing	
	R-30	R-38
4/12	0.036	0.031
5/12	0.035	0.030
6/12	0.034	0.029
7/12	0.034	0.029
8/12	0.034	0.028
9/12	0.034	0.028
10/12	0.033	0.028
11/12	0.033	0.027
12/12	0.033	0.027

Vented scissors truss attics assume a ceiling pitch of 2/12 with a roof pitch of either 4/12 or 5/12. Unbaffled standard framed scissors truss attics are assumed to have a void fraction of 0.016.

Vaulted Ceilings: Insulation is assumed to be fiberglass batts installed in roof joist cavities. In the vented case, at least 1.5 inches between the top of the batts and the underside of the roof sheathing is left open for ventilation in each cavity. A ventilation rate of 3.0 air changes per hour is assumed. In the unvented or dense pack case, the ceiling cavity is assumed to be fully packed with insulation, leaving no space for ventilation.

> **EXCEPTION:** Where polyurethane foam meets the requirements of Section 502.1.6.3 or 1313.2, the cavity shall be filled to the depth to achieve R-value requirements.

Roof Decks: Rigid insulation is applied to the top of roof decking with no space left for ventilation. Roofing materials are attached directly on top of the insulation. Framing members are often left exposed on the interior side.

Metal Truss Framing: Overall system tested values for the roof/ceiling U_o for metal framed truss assemblies from approved laboratories shall be used, when such data is acceptable to the building official.

Alternatively, the U_o for roof/ceiling assemblies using metal truss framing may be obtained from Tables 10-7A, 10-7B, 10-7C, 10-7D, and 10-7E.

Steel Truss Framed Ceiling, Table 10-7A.

Steel Truss Framed Ceiling with R-3 Sheathing, Table 10-7B.

Steel Truss Framed Ceiling with R-5 Sheathing, Table 10-7C.

Steel Truss Framed Ceiling with R-10 Sheathing, Table 10-7D.

Steel Truss Framed Ceiling with R-15 Sheathing, Table 10-7E.

Metal Building Roof, Table 10-7F: The base assembly is a roof where the insulation is compressed when installed beneath metal roof panels attached to the steel structure (purlins). Additional assemblies include continuous insulation, uncompressed and uninterrupted by framing.

Single Layer. The rated R-value of insulation is for insulation installed perpendicular to and draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

Double Layer. The first rated R-value of insulation is for insulation installed perpendicular to and draped over purlins. The second rated R-value of insulation is for unfaced insulation installed above the first layer and parallel to the purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

Continuous Insulation. For continuous insulation (e.g., insulation boards or blankets), it is assumed that the insulation is installed below the purlins and is uninterrupted by framing members. Insulation exposed to the conditioned space or semiheated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

Liner System (Ls). A continuous membrane is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the last rated R-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

Filled Cavity. The first rated R-value of insulation is for faced insulation installed parallel to the purlins. The second rated R-value of insulation is for unfaced insulation installed above the first layer, parallel to and between the purlins and compressed when the metal roof panels are attached. The facer of the first layer of insulation is of sufficient width to be continuously sealed to the top flange of the purlins and to accommodate the full thickness of the second layer of insulation. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of the second layer of insulation being installed above it. A minimum R-5 (R-0.9) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

U-factors for Metal Building Roofs. U-factors for metal building roofs shall be taken from Table 10-7F, provided the average purlin spacing is at least 52 in. and the R-value of the thermal spacer block is greater than or equal to the thermal spacer block R-value indicated in Table 10-7F for the assembly. It is not acceptable to use the U-factors in Table 10-7F if additional insulated sheathing is not continuous.

Roofs with Insulation Entirely Above Deck (uninterrupted by framing), Table 10-7G: The base assembly is continuous insulation over a structural deck. Added insulation is continuous and uninterrupted by framing. For the insulation, the first column lists the R-value for continuous insulation with a uniform thickness; the second column lists the comparable area-weighted average R-value for continuous insulation provided that the insulation thickness is never less than R-5 (except at roof drains) and that the slope is no greater than 1/4 inch per foot.

TABLE 10-7
DEFAULT U-FACTORS FOR CEILINGS

	Standard Frame	Advanced Frame
Ceilings Below Vented Attics		
Flat	**Baffled**	
R-19	0.049	0.047
R-30	0.036	0.032
R-38	0.031	0.026
R-49	0.027	0.020
R-60	0.025	0.017
Scissors Truss		
R-30 (4/12 roof pitch)	0.043	0.031
R-38 (4/12 roof pitch)	0.040	0.025
R-49 (4/12 roof pitch)	0.038	0.020
R-30 (5/12 roof pitch)	0.039	0.032
R-38 (5/12 roof pitch)	0.035	0.026
R-49 (5/12 roof pitch)	0.032	0.020
Vaulted Ceilings	**16" O.C.**	**24" O.C.**
Vented		
R-19 2x10 joist	0.049	0.048
R-30 2x12 joist	0.034	0.033
R-38 2x14 joist	0.027	0.027
Unvented		
R-30 2x10 joist	0.034	0.033
R-38 2x12 joist	0.029	0.027
R-21 + R-21 2x12 joist	0.026	0.025
Roof Deck	**4x Beams, 48" O.C.**	
R-12.5 2" Rigid insulation	0.064	
R-21.9 3.5" Rigid insulation	0.040	
R-37.5 6" Rigid insulation	0.025	
R-50 8" Rigid insulation	0.019	

TABLE 10-7A
STEEL TRUSS[1] FRAMED CEILING U_O

Cavity R-value	Truss Span (ft)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.1075	0.0991	0.0928	0.0878	0.0839	0.0807	0.0780	0.0757	0.0737	0.0720	0.0706	0.0693	0.0681
30	0.0907	0.0823	0.0760	0.0710	0.0671	0.0638	0.0612	0.0589	0.0569	0.0552	0.0538	0.0525	0.0513
38	0.0844	0.0759	0.0696	0.0647	0.0607	0.0575	0.0548	0.0525	0.0506	0.0489	0.0474	0.0461	0.0449
49	0.0789	0.0704	0.0641	0.0592	0.0552	0.0520	0.0493	0.0470	0.0451	0.0434	0.0419	0.0406	0.0395

TABLE 10-7B
STEEL TRUSS[1] FRAMED CEILING U_O WITH R-3 SHEATHING

Cavity R-value	Truss Span (ft)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0809	0.0763	0.0728	0.0701	0.0679	0.0661	0.0647	0.0634	0.0623	0.0614	0.0606	0.0599	0.0592
30	0.0641	0.0595	0.0560	0.0533	0.0511	0.0493	0.0478	0.0466	0.0455	0.0446	0.0438	0.0431	0.0424
38	0.0577	0.0531	0.0496	0.0469	0.0447	0.0430	0.0415	0.0402	0.0392	0.0382	0.0374	0.0367	0.0361
49	0.0523	0.0476	0.0441	0.0414	0.0393	0.0375	0.0360	0.0348	0.0337	0.0328	0.0319	0.0312	0.0306

TABLE 10-7C
STEEL TRUSS[1] FRAMED CEILING U_O WITH R-5 SHEATHING

Cavity R-value	Truss Span (ft)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0732	0.0697	0.0670	0.0649	0.0633	0.0619	0.0608	0.0598	0.0590	0.0583	0.0577	0.0571	0.0567
30	0.0564	0.0529	0.0502	0.0481	0.0465	0.0451	0.0440	0.0430	0.0422	0.0415	0.0409	0.0403	0.0399
38	0.0501	0.0465	0.0438	0.0418	0.0401	0.0388	0.0376	0.0367	0.0359	0.0351	0.0345	0.0340	0.0335
49	0.0446	0.0410	0.0384	0.0363	0.0346	0.0333	0.0322	0.0312	0.0304	0.0297	0.0291	0.0285	0.0280

TABLE 10-7D
STEEL TRUSS[1] FRAMED CEILING U_O WITH R-10 SHEATHING

Cavity R-value	Truss Span (ft)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0626	0.0606	0.0590	0.0578	0.0569	0.0561	0.0555	0.0549	0.0545	0.0541	0.0537	0.0534	0.0531
30	0.0458	0.0437	0.0422	0.0410	0.0401	0.0393	0.0387	0.0381	0.0377	0.0373	0.0369	0.0366	0.0363
38	0.0394	0.0374	0.0359	0.0347	0.0337	0.0330	0.0323	0.0318	0.0313	0.0309	0.0305	0.0302	0.0299
49	0.0339	0.0319	0.0304	0.0292	0.0283	0.0275	0.0268	0.0263	0.0258	0.0254	0.0251	0.0247	0.0245

TABLE 10-7E
STEEL TRUSS[1] FRAMED CEILING U_O WITH R-15 SHEATHING

Cavity R-value	Truss Span (ft)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0561	0.0550	0.0541	0.0535	0.0530	0.0526	0.0522	0.0519	0.0517	0.0515	0.0513	0.0511	0.0509
30	0.0393	0.0382	0.0373	0.0367	0.0362	0.0358	0.0354	0.0351	0.0349	0.0347	0.0345	0.0343	0.0341
38	0.0329	0.0318	0.0310	0.0303	0.0298	0.0294	0.0291	0.0288	0.0285	0.0283	0.0281	0.0279	0.0278
49	0.0274	0.0263	0.0255	0.0249	0.0244	0.0239	0.0236	0.0233	0.0230	0.0228	0.0226	0.0225	0.0223

1. Assembly values based on 24 inch on center truss spacing; 11 Truss member connections penetrating insulation (4 at the eaves, 7 in the interior space); ½ inch drywall ceiling; all truss members are 2x4 "C" channels with a solid web.
2. Ceiling sheathing installed between bottom chord and drywall.

TABLE 10-7F
DEFAULT U-FACTORS FOR METAL BUILDING ROOFS

Insulation System	Rated R-Value of Insulation	Overall U-Factor for Entire Base Roof Assembly	Overall U-Factor for Assembly of Base Roof Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation					
			R-6.5	R-13	R-19.5	R-26	R-32.5	R-39
Standing Seam Roofs with Thermal Spacer Blocks[a,b]								
Single Layer	None	1.280	0.137	0.073	0.049	0.037	0.030	0.025
	R-10	0.115	0.066	0.046	0.035	0.029	0.024	0.021
	R-11	0.107	0.063	0.045	0.035	0.028	0.024	0.021
	R-13	0.101	0.061	0.044	0.034	0.028	0.024	0.020
	R-16	0.096	0.059	0.043	0.033	0.027	0.023	0.020
	R-19	0.082	0.053	0.040	0.031	0.026	0.022	0.020
	R-10 .+ R-10	0.088	0.056	0.041	0.032	0.027	0.023	0.020
	R-10 .+ R-11	0.086	0.055	0.041	0.032	0.027	0.023	0.020
	R-11 .+ R-11	0.085	0.055	0.040	0.032	0.026	0.023	0.020
	R-10 .+ R-13	0.084	0.054	0.040	0.032	0.026	0.023	0.020
Double Layer	R-11 .+ R-13	0.082	0.053	0.040	0.032	0.026	0.022	0.020
	R-13 .+ R-13	0.075	0.050	0.038	0.030	0.025	0.022	0.019
	R10 .+ R-19	0.074	0.050	0.038	0.030	0.025	0.022	0.019
	R-11 .+ R-19	0.072	0.049	0.037	0.030	0.025	0.022	0.019
	R-13 .+ R-19	0.068	0.047	0.036	0.029	0.025	0.021	0.019
	R-16 .+ R-19	0.065	0.046	0.035	0.029	0.024	0.021	0.018
	R-19 .+ R-19	0.060	0.043	0.034	0.028	0.023	0.020	0.018
	R-19 .+ R-11	0.035						
Liner System	R-25 .+ R-11	0.031						
	R-30 .+ R-11	0.029						
	R-25 .+ R-11 .+ R-11	0.026						
Filled Cavity with Thermal Spacer Blocks[c]								
	R-10 .+ R-19	0.057	0.042	0.033	0.027	0.023	0.020	0.018
Standing Seam Roofs without Thermal Spacer Blocks								
Liner System	R-19 .+ R-11	0.040						
Thru-Fastened Roofs without Thermal Spacer Blocks								
Liner System	R-10	0.184						
	R-11	0.182						
	R-13	0.174						
	R-16	0.157						
	R-19	0.151						
	R-19 .+ R-11	0.044						

(Multiple R-values are listed in order from inside to outside)

a. A standing seam roof clip that provides a minimum 1.5 in. distance between the top of the purlins and the underside of the metal roof panels is required.

b. A minimum R-3 thermal spacer block is required.

c. A minimum R-5 thermal spacer block is required.

TABLE 10-7G
ASSEMBLY U-FACTORS FOR ROOFS WITH INSULATION ENTIRELY ABOVE DECK (UNINTERRUPTED BY FRAMING)

Rated R-Value of Insulation Alone: Minimum Throughout, Unsloped	Rated R-Value of Insulation Alone: Average (R-5 minimum), Sloped (1/4 inch per foot maximum)	Overall U-Factor for Entire Assembly
R-0	Not Allowed	U-1.282
R-1	Not Allowed	U-0.562
R-2	Not Allowed	U-0.360
R-3	Not Allowed	U-0.265
R-4	Not Allowed	U-0.209
R-5	Not Allowed	U-0.173
R-6	R-7	U-0.147
R-7	R-8	U-0.129
R-8	R-9	U-0.114
R-9	R-10	U-0.102
R-10	R-12	U-0.093
R-11	R-13	U-0.085
R-12	R-15	U-0.078
R-13	R-16	U-0.073
R-14	R-18	U-0.068
R-15	R-20	U-0.063
R-16	R-22	U-0.060
R-17	R-23	U-0.056
R-18	R-25	U-0.053
R-19	R-27	U-0.051
R-20	R-29	U-0.048
R-21	R-31	U-0.046
R-22	R-33	U-0.044
R-23	R-35	U-0.042
R-24	R-37	U-0.040
R-25	R-39	U-0.039
R-26	R-41	U-0.037
R-27	R-43	U-0.036
R-28	R-46	U-0.035
R-29	R-48	U-0.034
R-30	R-50	U-0.032
R-35	R-61	U-0.028
R-40	R-73	U-0.025
R-45	R-86	U-0.022
R-50	R-99	U-0.020
R-55	R-112	U-0.018
R-60	R-126	U-0.016

SECTION 1008 -- AIR INFILTRATION

1008.1 General: Tables 10-8 and 10-8A list effective air change rates and heat capacities for heat loss due to infiltration for Single-Family Residential.

The estimated seasonal average infiltration rate in air changes per hour (ACH) is given for standard air-leakage control (see Section 502.4 of this Code for air leakage requirements for Single-Family Residential). The effective air change rate shall be used in calculations for compliance under either the Component Performance or Systems Analysis approaches.

Heat loss due to infiltration shall be computed using the following equation:

$Q_{infil} = ACH_{eff} * HCP$

Where:

Q_{infil} = Heat loss due to air infiltration.

ACH_{eff} = The effective air infiltration rate in Table 10-8.

HCP = The Heat Capacity Density Product for the appropriate elevation or climate zone as given below.

TABLE 10-8
ASSUMED EFFECTIVE AIR CHANGES PER HOUR

Air-Leakage Control Package	Air Changes per Hour	
	Natural	Effective
Standard	0.35	0.35

TABLE 10-8A
DEFAULT HEAT CAPACITY/DENSITY PRODUCT FOR AIR

Zone	Average Elevation	Heat Capacity/ Density
1	Mean Sea Level	0.0180 Btu/h•°F
2	2000	0.0168 Btu/h•°F
3	3000	0.0162 Btu/h•°F

SECTION 1009 — MASS

1009.1 General: Tables 10-9 and 10-10 list default mass values for concrete masonry construction. Calculations are based on standard ASHRAE values for heat-storage capacity as listed in Standard RS-1, Chapter 26.

Thermal capacity of furniture is ignored, as is heat storage beyond the first 4 inches of mass thickness. All mass is assumed to be in direct contact with the conditioned space. Concrete separated from the heated volume by other materials must multiply the listed concrete mass value by the result of the following formula:

Ln(R-value) x (-0.221) + 0.5

Where:

Ln = Natural log

R-value = R-value of material covering concrete

Note: All default values for covered concrete slabs have been adjusted according to this procedure.

1009.2 Mass Description: Mass is divided into two types: structural and additional.

Structural Mass: Includes heat-storage capacity of all standard building components of a typical residential structure, including floors, ceilings and interior and exterior walls in Btu/ft²•°F of floor area. It also assumes exterior wall, interior wall and ceiling surface area approximately equals three times the floor area.

Additional Mass: Includes any additional building material not part of the normal structure, which is added specifically to increase the building's thermal-storage capability. This category includes masonry fireplaces, water or trombe walls and extra layers of sheetrock. Coefficients are in Btu/ft²•°F of surface area of material exposed to conditioned space. The coefficient for water is in Btu/°F•gallon.

1009.3 Component Description: Light frame assumes 1 inch thick wood flooring with 5/8 inch sheetrock on ceilings and interior walls, and walls consisting of either 5/8 inch sheetrock or solid logs. Slab assumes a 4 inch concrete slab on or below grade, with 5/8 inch sheetrock on exterior and interior walls and ceiling, and with separate values for interior or exterior wall insulation. Adjustments for slab covering is based on R-value of material. Additional mass values are based on the density multiplied by the specific heat of the material adjusted for listed thickness.

TABLE 10-9
HEAT CAPACITY

	Partial Grout	Solid Grout
8" CMU	9.65	15.0
12" CMU	14.5	23.6
8" Brick	10.9	16.4
6" Concrete	NA	14.4

TABLE 10-10
DEFAULT MASS VALUES

Structural Mass M-value	Btu/ft^2•°F floor area
Light Frame:	
Joisted/post & beam floor, sheetrock walls and ceilings	3.0
Joisted/post & beam floor, log walls, sheetrock ceilings	4.0
Slab With Interior Wall Insulation:	
Slab, no covering or tile, sheetrock walls and ceilings	10.0
Slab, hardwood floor covering, sheetrock walls and ceilings	7.0
Slab, carpet and pad, sheetrock walls and ceilings	5.0
Slab With Exterior Wall Insulation:	
Slab, no covering or tile, sheetrock walls and ceilings	12.0
Slab, hardwood floor covering, sheetrock walls and ceilings	9.0
Slab, carpet and pad, sheetrock walls and ceilings	7.0
Additional Mass M-Value:	**Btu/ft^2•°F surface area**
Gypsum wallboard, ½ inch thickness	0.54
Gypsum wallboard, 5/8 inch thickness	0.68
Hardwood floor	1.40
Concrete/Brick, 4 inch thickness	10.30
Concrete/Brick, 6 inch thickness	15.40
	Btu/°F•gallon
Water, 1 gallon	8.0

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CHAPTER 11
ADMINISTRATION AND ENFORCEMENT

SECTION 1100 — TITLE

Chapters 11 through 20 of this Code shall be known as the "Washington State Nonresidential Energy Code" and may be cited as such; and will be referred to hereafter as "this Code."

SECTION 1110 — PURPOSE AND INTENT

The purpose of this Code is to provide minimum standards for new or altered buildings and structures or portions thereof to achieve efficient use and conservation of energy. It is intended that these provisions provide flexibility to permit the use of innovative approaches and techniques to achieve efficient use and conservation of energy.

The purpose of this Code is not to create or otherwise establish or designate any particular class or group of persons who will or should be especially protected or benefited by the terms of this Code. This Code is not intended to abridge any safety or health requirements required under any other applicable codes or ordinances.

The provisions of this Code do not consider the efficiency of various energy forms as they are delivered to the building envelope.

SECTION 1120 — SCOPE

This Code sets forth minimum requirements for the design and commissioning of new or altered buildings and structures or portions thereof that provide facilities or shelter for public assembly, educational, business, mercantile, institutional, storage, factory, industrial, and multifamily residential occupancies by regulating their exterior envelopes and the selection of their mechanical systems, domestic water systems, electrical distribution and illuminating systems, and equipment for efficient use and conservation of energy.

EXCEPTION: The provisions of this code do not apply to temporary growing structures used solely for the commercial production of horticultural plants including ornamental plants, flowers, vegetables, and fruits. "Temporary growing structure" means a structure that has the sides and roof covered with polyethylene, polyvinyl, or similar flexible synthetic material and is used to provide plants with either frost protection or increased heat retention. A temporary growing structure is not considered a building for purposes of this Code.

SECTION 1130 — APPLICATION TO EXISTING BUILDINGS

Additions, alterations or repairs, changes of occupancy or use, or historic buildings that do not comply with the requirements for new buildings shall comply with the requirements in Sections 1130 through 1134 as applicable.

EXCEPTION: The building official may approve designs of alterations or repairs which do not fully conform with all of the requirements of Sections 1130 through 1134 where in the opinion of the building official full compliance is physically impossible and/or economically impractical and the alteration or repair improves the energy efficiency of the building.

In no case shall energy code requirements be less than those requirements in effect at the time of the initial construction of the building.

1131 Additions to Existing Buildings: Additions to existing buildings or structures may be constructed without making the entire building or structure comply, provided that the new additions shall conform to the provisions of this Code.

EXCEPTION: New additions which do not fully comply with the requirements of this Code and which have a floor area which is less than 750 ft^2 may be approved provided that improvements are made to the existing building to compensate for any deficiencies in the new addition. Compliance shall be demonstrated by either systems analysis per Section 1141.4 or component performance calculations per Sections 1330 through 1334. The nonconforming addition and upgraded existing building shall have an energy budget or target UA and SHGC that are less than or equal to the unimproved existing building, with the addition designed to comply with this Code. These additions are also exempt from Section 1314.6.

1132 Alterations and Repairs: Alterations and repairs to buildings or portions thereof originally constructed subject to the requirements of this Code shall conform to the provisions of this Code without the use of the exception in Section 1130. Other alterations and repairs may be made to existing buildings and moved buildings without making the entire building comply with all of the requirements of this Code for new buildings, provided the following requirements are met:

1132.1 Building Envelope: Alterations or repairs shall comply with nominal R-values and glazing requirements in Table 13-1 or 13-2.

EXCEPTIONS: 1. Storm windows installed over existing glazing.

2. Glass replaced in existing sash and frame provided that glazing is of equal or lower U-factor.

3. For solar heat gain coefficient compliance, glazing with a solar heat gain coefficient equal to or lower than that of the other existing glazing.

4. Existing roof/ceiling, wall or floor cavities exposed during construction provided that these cavities are insulated to full depth with insulation having a minimum nominal value of R-3.0 per inch installed per Sections 1311 and 1313.

5. Existing walls and floors without framing cavities, provided that any new cavities added to existing walls and floors comply with Exception 4.

6. Existing roofs where the roof membrane is being replaced and
   a. The roof sheathing or roof insulation is not exposed; or
   b. If there is existing roof insulation below the deck.

In no case shall the energy efficiency of the building be decreased.

1132.2 Mechanical Systems: Those parts of systems which are altered or replaced shall comply with Chapter 14 of this Code. Additions or alterations shall not be made to an existing mechanical system that will cause the existing mechanical system to become out of compliance.

All new systems in existing buildings, including packaged unitary equipment and packaged split systems, shall comply with Chapter 14.

Where mechanical cooling is added to a space that was not previously cooled, the mechanical cooling system shall comply with Sections 1413 and either 1423 or 1433.

Exceptions: These exceptions only apply to situations where mechanical cooling is added to a space that was not previously cooled.

1. Water-cooled refrigeration equipment provided with a water economizer meeting the requirements of Section 1413 need not comply with 1423 or 1433. This exception shall not be used for RS-29 analysis.

2. Alternate designs that are not in full compliance with this Code may be approved when the building official determines that existing building or occupancy constraints make full compliance impractical or where full compliance would be economically impractical.

Alterations to existing mechanical cooling systems shall not decrease economizer capacity unless the system complies with Section 1413 and either 1423 or 1433. In addition, for existing mechanical cooling systems that do not comply with Sections 1413 and either 1423 or 1433, including both the individual unit size limits and the total building capacity limits on units without economizer, other alterations shall comply with Table 11-1.

When space cooling equipment is replaced, controls shall be installed to provide for integrated operation with economizer in accordance with Section 1413.3.

Existing equipment currently in use may be relocated within the same floor or same tenant space if removed and reinstalled within the same permit.

1132.3 Lighting and Motors: Where the use in a space changes from one use in Table 15-1 to another use in Table 15-1, the installed lighting wattage shall comply with Section 1521 or 1531.

Other tenant improvements, alterations or repairs where 60 percent or more of the fixtures in a space enclosed by walls or ceiling-height partitions are new shall comply with Sections 1531 and 1532. (Where this threshold is triggered, the areas of the affected spaces may be combined for lighting code compliance calculations.) Where less than 60 percent of the fixtures in a space enclosed by walls or ceiling-height partitions are new, the installed lighting wattage shall be maintained or reduced. Where 60 percent or more of the lighting fixtures in a suspended ceiling are new, and the existing insulation is on the suspended ceiling, the roof/ceiling assembly shall be insulated according to the provisions of Chapter 13, Section 1311.2.

Where new wiring is being installed to serve added fixtures and/or fixtures are being relocated to a new circuit, controls shall comply with Sections 1513.1 through 1513.5 and, as applicable, 1513.8. In addition, office areas less than 300 ft^2 enclosed by walls or ceiling-height partitions, and all meeting and conference rooms, and all school classrooms, shall be equipped with occupancy sensors that comply with Section 1513.6 and 1513.8. Where a new lighting panel (or a moved lighting panel) with all new raceway and conductor wiring from the panel to the fixtures is being installed, controls shall also comply with the other requirements in Sections 1513.6 through 1513.8.

Where new walls or ceiling-height partitions are added to an existing space and create a new enclosed space, but the lighting fixtures are not being changed, other than being relocated, the new enclosed space shall have controls that comply with Sections 1513.1 through 1513.2, 1513.4, and 1513.6 through 1513.8.

Those motors which are altered or replaced shall comply with Section 1511.

1133 Change of Occupancy or Use: Changes of occupancy or use shall comply with the following requirements:

a. Any unconditioned space that is altered to become semi-heated, cooled, or fully heated, or any semi-heated space that is altered to become cooled or fully heated space shall be required to be brought into full compliance with this Code.

b. Any nonresidential space which is converted to multi-family residential space shall be brought into full compliance with this Code.

c. Any multi-family residential space which is converted to nonresidential space shall be required to comply with all of the provisions of Sections 1130 through 1132 of this Code.

1134 Historic Buildings: The building official may modify the specific requirements of this Code for historic buildings and require in lieu thereof alternate requirements which will result in a reasonable degree of energy efficiency. This modification may be allowed for those buildings which have been specifically designated as historically significant by the state or local governing body, or listed in The National Register of Historic Places or which have been determined to be eligible for listing.

1135 Commissioning: Commissioning in compliance with Sections 1416 and 1513.8 shall be required for new systems or modified portions of systems, with a heating capacity of 600,000 Btu/h or a cooling capacity of 40 tons or more.

SECTION 1140 — ENFORCEMENT

The building official shall have the power to render interpretations of this Code and to adopt and enforce rules and supplemental regulations in order to clarify the application of its provisions. Such interpretations, rules and regulations shall be in conformance with the intent and purpose of this Code. Fees may be assessed for enforcement of this Code and shall be as set forth in the fee schedule adopted by the jurisdiction.

1141 Plans and Specifications

1141.1 General: If required by the building official, plans and specifications shall be submitted in support of an application for a building permit. If required by the building official, plans and specifications shall be stamped and authenticated by a registered design professional currently licensed in the state of Washington. All plans and specifications, together with supporting data, shall be submitted to the building official prior to issuance of a building permit.

1141.2 Details: The plans and specifications shall show in sufficient detail all pertinent data and features of the building and the equipment and systems as herein governed including, but not limited to: design criteria; exterior envelope component materials, U-factors of the envelope systems, R-values of insulating materials; U-factors and solar heat gain coefficients or shading coefficients of glazing; area weighted U-factor calculations; efficiency, economizer, size and type of apparatus and equipment; fan system horsepower; equipment and systems controls; lighting fixture schedule with wattages and controls narrative; commissioning requirements for HVAC equipment, HVAC controls, and lighting controls, and other pertinent data to indicate compliance with the requirements of this Code.

1141.3 Alternate Materials and Method of Construction: The provisions of this Code are 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 has been approved by the building official as meeting the intent of this Code. The building official may approve any such alternate provided the proposed alternate meets or exceeds the provisions of this Code and that the material, method, design or work offered is for the purpose intended, at least the equivalent of that prescribed in this Code, in quality, strength, effectiveness, fire-resistance, durability, safety and energy efficiency. The building official may require that sufficient evidence of proof be submitted to substantiate any claims that may be made regarding performance capabilities.

1141.4 Systems Analysis Approach for the Entire Building: In lieu of using Chapters 12 through 20, compliance may be demonstrated using the systems analysis option in Standard RS-29. When using systems analysis, the proposed building shall provide equal or better conservation of energy than the standard design as defined in Standard RS-29. If required by the building official, all energy comparison calculations submitted under the provisions of Standard RS-29 shall be stamped and authenticated by an engineer or architect licensed to practice by the state of Washington.

1141.5 Commissioning Details/Specifications: When required by the building official, the plans submitted in support of a building permit shall include a list of the functional tests required to comply with commissioning in accordance with Sections 1416 and 1513.8 as well as the name of the commissioning agent for buildings over 50,000 square feet.

1142 Materials and Equipment

1142.1 Identification: All materials and equipment shall be identified in order to show compliance with this Code.

1142.2 Maintenance Information: Maintenance instructions shall be furnished for any equipment which requires preventive maintenance for efficient operation. Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label. Such label may be limited to identifying, by title or publication number, the operation and maintenance manual for that particular model and type of product.

1143 Inspections

1143.1 General: All construction or work for which a permit is required shall be subject to inspection by the building official and all such construction or work shall remain accessible and exposed for inspection purposes until approved by the building official. No work shall be done on any part of the building or structure beyond the point indicated in each inspection without first obtaining the approval of the building official.

1143.2 Required Inspections: The building official, upon notification, shall make the inspection required in this section, in addition to or as part of those inspections required in Section 109.3 of the International Building Code. Inspections may be conducted by special inspection pursuant to Section 1704 of the International Building Code. Where applicable, inspections shall include at least:

1143.2.1 Envelope

a. Wall Insulation Inspection: To be made after all wall insulation and air vapor retarder sheet or film materials are in place, but before any wall covering is placed.
b. Glazing Inspection: To be made after glazing materials are installed in the building.

c. Exterior Roofing Insulation: To be made after the installation of the roof insulation, but before concealment.

d. Slab/Floor Insulation: To be made after the installation of the slab/floor insulation, but before concealment.

1143.2.2 Mechanical

a. Mechanical Equipment Efficiency and Economizer: To be made after all equipment and controls required by this Code are installed and prior to the concealment of such equipment or controls.

b. Mechanical Pipe and Duct Insulation: To be made after all pipe and duct insulation is in place, but before concealment.

1143.2.3 Lighting and Motors

a. Lighting Equipment and Controls: To be made after the installation of all lighting equipment and controls required by this Code, but before concealment of the lighting equipment.

b. Motor Inspections: To be made after installation of all equipment covered by this Code, but before concealment.

1143.3 Re-inspection: The building official may require a structure to be re-inspected. A re-inspection fee may be assessed for each inspection or re-inspection when such portion of work for which inspection is called is not complete or when corrections called for are not made.

1144 Violations: It shall be a violation of this Code for any person, firm or corporation to erect or construct any building, or remodel or rehabilitate any existing building or structure in the state, or allow the same to be done, contrary to any of the provisions of this Code.

SECTION 1150 — CONFLICTS WITH OTHER CODES

In case of conflicts among Codes enumerated in RCW 19.27.031 subsections (1), (2), (3) and (4) and this Code, the first named Code shall govern. The duct insulation requirements in this Code or a local jurisdiction's energy code, whichever is more stringent, supersede the requirements in the Mechanical Code.

Where, in any specific case, different sections of this Code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

SECTION 1160 — SEVERABILITY & LIABILITY

1161 Severability: If any provision of this Code or its application to any person or circumstance is held invalid, the remainder of this Code or the application of the provision to other persons or circumstances is not affected.

1162 Liability: Nothing contained in this Code is intended to be nor shall be construed to create or form the basis for any liability on the part of any city or county or its officers, employees or agents for any injury or damage resulting from the failure of a building to conform to the provisions of this Code.

TABLE 11-1:
ECONOMIZER COMPLIANCE OPTIONS FOR MECHANICAL ALTERATIONS

	Option A	Option B (alternate to A)	Option C (alternate to A)	Option D (alternate to A)
Unit Type	**Any alteration with new or replacement equipment**	**Replacement unit of the same type with the same or smaller output capacity**	**Replacement unit of the same type with a larger output capacity**	**New equipment added to existing system or replacement unit of a different type**
1. Packaged Units	Efficiency: min.[1] Economizer: 1433[2]	Efficiency: min.[1] Economizer: 1433[2,3]	Efficiency: min.[1] Economizer: 1433[2,3]	Efficiency: min.[1] Economizer: 1433[2,4]
2. Split Systems	Efficiency: min.[1] Economizer: 1433[2]	Efficiency: + 10/5%[5] Economizer: shall not decrease existing economizer capability	Only for new units < 54,000 Btuh replacing unit installed prior to 1991 (one of two): Efficiency: + 10/5%[5] Economizer: 50%[6] For units > 54,000 Btuh or any units installed after 1991: Option A	Efficiency: min.[1] Economizer: 1433[2,4]
3. Water Source Heat Pump	Efficiency: min.[1] Economizer: 1433[2]	(two of three): Efficiency: + 10/5%[5] Flow control valve[7] Economizer: 50%[6]	(three of three): Efficiency: + 10/5%[5] Flow control valve[7] Economizer: 50%[6] (except for certain pre-1991 systems[8])	Efficiency: min.[1] Economizer: 1433[2,4] (except for certain pre-1991 systems[8])
4. Hydronic Economizer using Air-Cooled Heat Rejection Equipment (Dry Cooler)	Efficiency: min.[1] Economizer: 1433[2]	Efficiency: + 10/5%[5] Economizer: shall not decrease existing economizer capacity	Option A	Efficiency: min.[1] Economizer: 1433[2,4]
5. Air-Handling Unit (including fan coil units) where the system has an air-cooled chiller	Efficiency: min.[1] Economizer: 1433[2]	Economizer: shall not decrease existing economizer capacity	Option A (except for certain pre-1991 systems[8])	Option A (except for certain pre-1991 systems[8])
6. Air- Handling Unit (including fan coil units) and Water-cooled Process Equipment, where the system has a water-cooled chiller[10]	Efficiency: min.[1] Economizer: 1433[2]	Economizer: shall not decrease existing economizer capacity	Option A (except for certain pre-1991 systems[8] and certain 1991-2004 systems[9].)	Efficiency: min.[1] Economizer: 1433[2,4] (except for certain pre-1991 systems[8] and certain 1991-2004 systems[9])
7. Cooling Tower	Efficiency: min.[1] Economizer: 1433[2]	No requirements	Option A	Option A
8. Air-Cooled Chiller	Efficiency: min.[1] Economizer: 1433[2]	Efficiency: + 5%[11] Economizer: shall not decrease existing economizer capacity	Efficiency (two of two): (1) + 10%[12] and (2) multistage Economizer: shall not decrease existing economizer capacity	Efficiency: min.[1] Economizer: 1433[2,4]

9. Water-Cooled Chiller	Efficiency: min.[1] Economizer: 1433[2]	Efficiency (one of two): (1) + 10%[13] or (2) plate frame heat exchanger[15] Economizer: shall not decrease existing economizer capacity	Efficiency (two of two): (1) + 15%[14] and (2) plate-frame heat exchanger[15] Economizer: shall not decrease existing economizer capacity	Efficiency: min.[1] Economizer: 1433[2,4]
10. Boiler	Efficiency: min.[1] Economizer: 1433[2]	Efficiency: + 8%[16] Economizer: shall not decrease existing economizer capacity	Efficiency: + 8%[16] Economizer: shall not decrease existing economizer capacity	Efficiency: min.[1] Economizer: 1433[2,4]

1. Minimum equipment efficiency shall comply with Section 1411.1 and Tables 14-1A through M.
2. System and building shall comply with Section 1433 (including both the individual unit size limits and the total building capacity limits on units without economizer). It is acceptable to comply using one of the exceptions to Section 1433.
3. All equipment replaced in an existing building shall have air economizer complying with Sections 1413 and 1433 unless both the individual unit size and the total capacity of units without air economizer in the building is less than that allowed in Exception 1 to Section 1433.
4. All separate new equipment added to an existing building shall have air economizer complying with Sections 1413 and 1433 unless both the individual unit size and the total capacity of units without air economizer in the building is less than that allowed in Exception 1 to Section 1433.
5. Equipment shall have a capacity-weighted average cooling system efficiency:
   a. for units with a cooling capacity below 54,000 Btuh, a minimum of 10% greater than the requirements in Tables 14-1A and 14-1B (1.10 x values in Tables 14-1A and 14-1B).
   b. for units with a cooling capacity of 54,000 Btuh and greater, a minimum of 5% greater than the requirements in Tables 14-1A and 14-1B (1.05 x values in Tables 14-1A and 14-1B).
6. Minimum of 50% air economizer that is ducted in a fully enclosed path directly to every heat pump unit in each zone, except that ducts may terminate within 12 inches of the intake to an HVAC unit provided that they are physically fastened so that the outside air duct is directed into the unit intake. If this is an increase in the amount of outside air supplied to this unit, the outside air supply system shall be capable of providing this additional outside air and equipped with economizer control.
7. Have flow control valve to eliminate flow through the heat pumps that are not in operation with variable speed pumping control complying with Section 1432.2.2 for that heat pump.
   – When the total capacity of all units with flow control valves exceeds 15% of the total system capacity, a variable frequency drive shall be installed on the main loop pump.
   – As an alternate to this requirement, have a capacity-weighted average cooling system efficiency that is 5% greater than the requirements in note 5 (i.e. a minimum of 15%/10% greater than the requirements in Tables 14-1A and 14-1B (1.15/1.10 x values in Tables 14-1A and 14-1B)).
8. Systems installed prior to 1991 without fully utilized capacity are allowed to comply with Option B, provided that the individual unit cooling capacity does not exceed 90,000 Btuh.
9. Economizer not required for systems installed with water economizer plate and frame heat exchanger complying with previous codes between 1991 and June 2004, provided that the total fan coil load does not exceed the existing or added capacity of the heat exchangers.
10. For water-cooled process equipment where the manufacturers specifications require colder temperatures than available with waterside economizer, that portion of the load is exempt from the economizer requirements.
11. The air-cooled chiller shall have an IPLV efficiency that is a minimum of 5% greater than the IPLV requirements in Table 14-1C (1.05 x IPLV values in Table 14-1C).
12. The air-cooled chiller shall:
    a. have an IPLV efficiency that is a minimum of 10% greater than the IPLV requirements in Table 14-1C (1.10 x IPLV values in Table 14-1C), and
    b. be multistage with a minimum of two compressors.
13. The water-cooled chiller shall have an NPLV efficiency that is a minimum of 10% greater than the NPLV requirements in Table 14-1K, Table 14-1L, or Table 14-1M (1.10 x NPLV values in Table 14-1K, Table 14-1L, or Table 14-1M).
14. The water-cooled chiller shall have an NPLV efficiency that is a minimum of 15% greater than the NPLV requirements in Table 14-1K, Table 14-1L, or Table 14-1M (1.15 x NPLV values in Table 14-1K, Table 14-1L, or Table 14-1M).
15. Economizer cooling shall be provided by adding a plate-frame heat exchanger on the waterside with a capacity that is a minimum of 20% of the chiller capacity at standard AHRI rating conditions.
16. The replacement boiler shall have an efficiency that is a minimum of 8% higher than the value in Table 14-1F (1.08 x value in Table 14-1F), except for electric boilers.

CHAPTER 12
ENERGY METERING

1201 General. All buildings shall comply with Chapter 12. Whole building energy supply sources shall be metered to supply energy consumption data to the building owner to effectively manage energy. The building shall have a totalizing meter for each energy source.

1202 Whole Building Energy Supply Metering. Meters with remote metering capability or automatic meter reading (AMR) capability shall be provided to collect energy use data for each energy supply source to the building including gas, electricity and district stream, that exceeds the thresholds listed in Table 12-1. Utility company service entrance/interval meters are allowed to be used provided that they are configured for automatic meter reading (AMR) capability.

Master submetering with remote metering capability (including current sensors or flow meters) shall be provided for the systems that exceed the thresholds in Table 12-1 to collect overall totalized energy use data for each subsystem in accordance with Table 12-2.

Metering shall be digital-type meters for the main meter. Current sensors or flow meters are allowed for submetering. For subsystems with multiple similar units, such as multicell cooling towers, only one meter is required for the subsystem. Existing buildings are allowed to reuse installed existing analog-type utility company service/interval meters.

1203 Metering: Where new or replacement systems or equipment is installed that exceeds the threshold in Table 12-1 or Table 12-2, metering shall be installed for that system or equipment in accordance with Section 1201.

TABLE 12-1
ENERGY SOURCE METER THRESHOLDS

Energy Source	Main Metering Threshold
Electrical service	> 500 kVA
On-site renewable electric power	> 10 kVA (peak)
Gas and steam service	> 300 kW (1,000,000 Btu/h)
Geothermal	> 300 kW (1,000,000 Btu/h) heating
On-site renewable thermal energy	> 10 kW (30,000 Btu/h)

TABLE 12-2
COMPONENT ENERGY MASTER SUBMETERING THRESHOLDS

Component	Submetering Threshold
Chillers/heat pump systems	> 70 kW (240,000 Btu/h) cooling capacity
Packaged AC unit systems	> 70 kW (240,000 Btu/h) cooling capacity
HVAC fan systems	> 15 kW (20 hp)
Exhaust fan systems	> 15 kW (20 hp)
Make-up air fan systems	> 15 kW (20 hp)
Pump systems	> 15 kW (20 hp)
Cooling towers systems	> 15 kW (20 hp)
Boilers, furnaces and other heating equipment systems	> 300 kW (1,000,000 Btu/h) heating capacity
General lighting circuits	> 15 kVA
Miscellaneous electric loads	> 15 kVA

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CHAPTER 13
BUILDING ENVELOPE

1301 Scope: Conditioned buildings or portions thereof shall be constructed to provide the required thermal performance of the various components according to the requirements of this chapter. Unless otherwise approved by the building official, all spaces shall be assumed to be at least semi-heated.

EXCEPTIONS: 1. Greenhouses isolated from any conditioned space and not intended for occupancy.

2. As approved by the building official, spaces not assumed to be at least semi-heated.

3. Unconditioned Group U occupancy accessory to Group R occupancy.

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

1302 Space Heat Type: For the purpose of determining building envelope requirements, the following two categories comprise all space heating types:

Electric Resistance: Space heating systems which use electric resistance elements as the primary heating system including baseboard, radiant and forced air units where the total electric resistance heat capacity exceeds 1.0 W/ft^2 of the gross conditioned floor area.

EXCEPTION: Heat pumps and terminal electric resistance heating in variable air volume distribution systems.

Other: All other space heating systems including gas, solid fuel, oil and propane space heating systems and those systems listed in the exception to electric resistance.

1303 Climate Zones: All buildings shall comply with the requirements of the appropriate climate zone as defined herein.

ZONE 1: Climate Zone 1 shall include all counties not included in Climate Zone 2.

ZONE 2: Adams, Chelan, Douglas, Ferry, Grant, Kittitas, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens and Whitman counties.

SECTION 1310 — GENERAL REQUIREMENTS

The building envelope shall comply with Sections 1311 through 1314.

1310.1 Conditioned Spaces: The building envelope for conditioned spaces shall also comply with one of the following paths:

a. Prescriptive Building Envelope Option Sections 1320 through 1323.

b. Component Performance Building Envelope Option Sections 1330 through 1334.

c. Systems Analysis. See Section 1141.4.

1310.2 Semi-Heated Spaces: All spaces shall be considered conditioned spaces, and shall comply with the requirements in Section 1310.1 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).

For semi-heated spaces, the building envelope shall comply with the same requirements as that for conditioned spaces in Section 1310.1; however, semi-heated spaces shall be calculated separately from other conditioned spaces for compliance purposes.

EXCEPTION: For semi-heated spaces heated by other fuels only, wall insulation is not required for those walls that separate semi-heated spaces (see definition in Section 201.1) from the exterior provided that the space is heated solely by a heating system controlled by a thermostat with a maximum setpoint capacity of 45°F, mounted no lower than the heating unit.

FIGURE 13A
BUILDING ENVELOPE COMPLIANCE OPTIONS

Section Number	Subject	Prescriptive Option	Component Performance Option	Systems Analysis Option
1310	General Requirements	X	X	X
1311	Insulation	X	X	X
1312	Glazing and Doors	X	X	X
1313	Moisture Control	X	X	X
1314	Air Leakage	X	X	X
1320	Prescriptive Building Envelope Option	X		
1321	General	X		
1322	Opaque Envelope	X		
1323	Glazing	X		
1330	Component Performance Building Envelope Option		X	
1331	General		X	
1332	Component U-Factors		X	
1333	UA Calculations		X	
1334	Solar Heat Gain Coefficient		X	
RS-29	Systems Analysis			X

1310.3 Cold Storage and Refrigerated Spaces: Exterior and interior surfaces of frozen storage spaces or cold storage spaces in refrigerated warehouses may comply with either the prescriptive or component performance approach using insulation values in Table 13-3. The remainder of refrigerated warehouse area containing conditioned or semi-conditioned spaces shall comply by using either the prescriptive or component performance approach using Tables 13-1 and 13-2.

EXCEPTIONS: 1. Areas within refrigerated warehouses that are designed solely for the purpose of quick chilling or freezing of products with design cooling capacities of greater than 240 Btu/hr-ft^2 (2 tons per 100 ft^2).

2. Controlled atmosphere storage exterior floor and partition wall insulation.

TABLE 13-3
REFRIGERATED WAREHOUSE INSULATION

Space	Surface	Minimum R-Value (°F·hr·ft2/Btu)
Frozen Storage Spaces (28°F or below)	Exterior Roof/Ceiling	R-36
	Exterior Wall	R-36
	Exterior Floor	R-36
	Interior Partition[1]	R-28
Cold Storage Spaces (28°-45°F)	Exterior Roof/Ceiling	R-28
	Exterior Wall	R-28
	Interior Partition[1]	R-19

[1]Interior partitions include any wall, floor or ceiling that divides frozen storage spaces or cold storage spaces from each other, conditioned spaces, unconditioned spaces, or semi-conditioned spaces.

1311 Insulation

1311.1 Installation Requirements: All insulation materials shall be installed according to the manufacturer's instructions to achieve proper densities, maintain clearances and maintain uniform R-values. To the maximum extent possible, insulation shall extend over the full component area to the intended R-value.

1311.2 Roof/Ceiling Insulation: Where two or more layers of rigid board insulation are used in a roof assembly, the vertical joints between each layer shall be staggered. Open-blown or poured loose-fill insulation may be used in attic spaces where the slope of the ceiling is not more than 3/12 and there is at least 30 inches of clear distance from the top of the bottom chord of the truss or ceiling joist to the underside of the sheathing at the roof ridge. When eave vents are installed, baffling of the vent openings shall be provided so as to deflect the incoming air above the surface of the insulation.

Where lighting fixtures are recessed into a suspended or exposed grid ceiling, the roof/ceiling assembly shall be insulated in a location other than directly on the suspended ceiling.

EXCEPTION: Type IC rated recessed lighting fixtures.

Where installed in wood framing, faced batt insulation shall be face stapled.

1311.3 Wall Insulation: Exterior wall cavities isolated during framing shall be fully insulated to the levels of the surrounding walls. When installed in wood framing, faced batt insulation shall be face stapled.

Above grade exterior insulation shall be protected.

1311.4 Floor Insulation: Floor insulation shall be installed in a permanent manner in substantial contact with the surface being insulated. Insulation supports shall be installed so spacing is not more than 24 inches on center. Installed insulation shall not block the airflow through foundation vents.

1311.5 Slab-On-Grade Floor: Slab-on-grade insulation installed inside the foundation wall shall extend downward from the top of the slab a minimum distance of 24 inches or to the top of the footing, whichever is less. Insulation installed outside the foundation shall extend downward a minimum of 24 inches or to the frost line, whichever is greater. Above grade insulation shall be protected.

EXCEPTION: For monolithic slabs, the insulation shall extend downward from the top of the slab to the bottom of the footing.

1311.6 Radiant Floors (on or below grade): Slab-on-grade insulation shall extend downward from the top of the slab a minimum distance of 36 inches or downward to the top of the footing and horizontal for an aggregate of not less than 36 inches.

If required by the building official where soil conditions warrant such insulation, the entire area of a radiant floor shall be thermally isolated from the soil. Where a soil gas control system is provided below the radiant floor, which results in increased convective flow below the radiant floor, the radiant floor shall be thermally isolated from the sub-floor gravel layer.

1312 Glazing and Doors

1312.1 Standard Procedure for Determination of Glazing and Door U-Factors: U-factors for glazing and doors shall be determined, certified and labeled in accordance with Standard RS-31 by a certified independent agency licensed by the National Fenestration Rating Council (NFRC). Compliance shall be based on the Residential or the Nonresidential Model Size. Product samples used for U-factor determinations shall be production line units or representative of units as purchased by the consumer or contractor. Unlabeled glazing and doors shall be assigned the default U-factor in Table 10-6.

1312.2 Solar Heat Gain Coefficient and Shading Coefficient: Solar Heat Gain Coefficient (SHGC), shall be determined, certified and labeled in accordance with the National Fenestration Rating Council (NFRC) Standard by a certified, independent agency, licensed by the NFRC.

EXCEPTION: Shading coefficients (SC) shall be an acceptable alternate for compliance with solar heat gain coefficient requirements. Shading coefficients for glazing shall be taken from Chapter 15 of Standard RS-1 or from the manufacturer's test data.

1313 Moisture Control

1313.1 Vapor Retarders: Vapor retarders shall be installed on the warm side (in winter) of insulation as required by this section.

EXCEPTION: Vapor retarder installed with not more than 1/3 of the nominal R-value between it and the conditioned space.

1313.2 Roof/Ceiling Assemblies: Roof/ceiling assemblies where the ventilation space above the insulation is less than an average of 12 inches shall be provided with a vapor retarder. (For enclosed attics and enclosed rafter spaces, see Section 1203.2 of the International Building Code.) Roof/ceiling assemblies without a vented airspace, allowed only where neither the roof deck nor the roof structure are made of wood, shall provide a continuous vapor retarder with taped seams.

EXCEPTIONS: 1. Vapor retarders need not be provided where all of the insulation is installed between the roof membrane and the structural roof deck.

2. Unvented attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) shall be permitted if all of the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope.

2. No interior vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly.

3. Where wood shingles or shakes are used, a minimum ¼ inch (6 mm) vented air space separates the shingles or shakes and the roofing underlayment above the structural sheathing.

4. Any air-impermeable insulation shall be a vapor retarder, or shall have a vapor retarder coating or covering in direct contact with the underside of the insulation.

5. Either items a, b or c shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.

a. Air-impermeable insulation only. Insulation shall be applied in direct contact to the underside of the structural roof sheathing.

b. Air-permeable insulation only. In addition to the air-permeable insulation installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing as specified per WA Climate Zone for condensation control:

i. Climate Zone 1: R-10 minimum rigid board or air-impermeable insulation R-value.

ii. Climate Zone 2: R-25 minimum rigid board or air-impermeable insulation R-value.

c. Air-impermeable and air-permeable insulation. The air-impermeable insulation shall be applied in direct contact to the underside of the structural roof sheathing as specified per WA Climate Zone for condensation control. The air-permeable insulation shall be installed directly under the air impermeable insulation.

i. Climate Zone 1: R-10 minimum rigid board or air-impermeable insulation R-value.

ii. Climate Zone 2: R-25 minimum rigid board or air-impermeable insulation R-value.

1313.3 Walls: Walls separating conditioned space from unconditioned space shall be provided with a vapor retarder.

1313.4 Floors: Floors separating conditioned space from unconditioned space shall be provided with a vapor retarder.

1313.5 Crawlspaces: A ground cover of six mil (0.006 inch thick) black polyethylene or approved equal shall be laid over the ground within crawlspaces. The ground cover shall be overlapped 12 inches minimum at the joints and shall extend to the foundation wall.

EXCEPTION: The ground cover may be omitted in crawl spaces if the crawlspace has a concrete slab floor with a minimum thickness of 3-1/2 inches.

1314 Air Leakage

1314.1 Building Envelope Sealing: The following areas of the building envelope shall be sealed, caulked, gasketed or weather-stripped to minimize air leakage:

a. Joints around fenestration and door frames;

b. Junctions between walls and foundations, between walls at building corners, between walls and structural floors or roofs, and between walls and roof or roof panels;

c. Openings at penetrations of utility services through the roofs, walls and floors;

d. Site-built fenestration and doors;

e. Building assemblies used as ducts or plenums;

f. Joints, seams and penetrations of vapor retarders; and

g. All other openings in the building envelope.

1314.2 Glazing and Doors: Air leakage for fenestration and doors shall be determined in accordance with NFRC 400 or AAMA/WDMA/CSA 101/IS2/A440 or ASTM E283 as specified below. Air leakage shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council, and shall be labeled and certified by the manufacturer. Air leakage shall not exceed:

a. 1.0 cfm/ft^2 for glazed swinging entrance doors and revolving doors, tested at a pressure of at least 1.57 pounds per square foot (psf) in accordance with NFRC 400, AAMA/WDMA/CSA 101/IS2/A440, or ASTM E283.

b. 0.04 cfm/ft^2 for curtain wall and storefront glazing, tested at a pressure of at least 1.57 pounds per square foot (psf) in accordance with NFRC 400, AAMA/WDMA/CSA 101/IS2/A440, or ASTM E283.

c. 0.2 cfm/ft^2 for all other products when tested at a pressure of at least 1.57 pounds per square foot (psf) in accordance with NFRC 400 or AAMA/WDMA/CSA 101/IS2/A440, or 0.3 cfm/ft^2 when tested at a pressure of at least 6.24 pounds per square foot (psf) in accordance with AAMA/WDMA/CSA 101/I.S/A440.

EXCEPTIONS: 1. Openings that are required to be fire resistant.

2. Field-fabricated fenestration and doors that are weather-stripped or sealed in accordance with Section 1314.1.

3. For garage doors, air leakage determined by test at standard conditions in accordance with ANSI/DASMA 105 shall be an acceptable alternate for compliance with air leakage requirements.

4. Units without air leakage ratings produced by small business that are weather-stripped or sealed in accordance with Section 1314.1.

1314.3 Building Assemblies Used as Ducts or Plenums: Building assemblies used as ducts or plenums shall be sealed, caulked and gasketed to limit air leakage.

1314.4 Recessed Lighting Fixtures: When installed in the building envelope, recessed lighting fixtures shall by Type IC rated, and certified under ASTM E283 to have no more than 2.0 cfm air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested at 75 Pascals or 1.57 lbs/ft^2 pressure difference and have a label attached, showing compliance with this test method. Recessed lighting fixtures shall be installed with a gasket or caulk between the fixture and ceiling to prevent air leakage.

1314.5 Loading Dock Weatherseals: Cargo doors and loading dock doors shall be equipped with weatherseals to restrict infiltration when vehicles are parked in the doorway.

1314.6 Continuous Air Barrier: For buildings over five stories, the building envelope shall be designed and constructed with a continuous air barrier to control air leakage into, or out of, the conditioned space. All air barrier components of each envelope assembly shall be clearly identified on construction documents and the joints, interconnections and penetrations of the air barrier components shall be detailed.

1314.6.1 Characteristics: The continuous air barrier shall have the following characteristics:

a. The air barrier component of each assembly shall be joined and sealed in a flexible manner to the air barrier component of adjacent assemblies, allowing for the relative movement of these assemblies and components. This requirement shall not be construed to restrict the materials or methods by which the air barrier is achieved.

b. It shall be capable of withstanding positive and negative combined design wind, fan and stack pressures on the air barrier without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.

c. It shall be installed in accordance with the manufacturer's instructions and in such a manner as to achieve the performance requirements.

1314.6.2 Compliance: Compliance of the continuous air barrier for the opaque building envelope shall be demonstrated by testing the completed building and demonstrating that the air leakage rate of the building envelope does not exceed 0.40 cfm/ft^2 at a pressure differential of 0.3 inch w.g. (1.57 psf) as specified below.

a. Whole building testing shall be accomplished in accordance with ASTM E 779 or approved similar test. Tests shall be accomplished using either pressurization or depressurization or both. The building shall not be tested unless it is verified that the continuous air barrier is in place and installed without failures in accordance with installation instructions so that repairs to the continuous air barrier, if needed to comply with the required air leakage rate, can be done in a timely manner. Following are comments referring to ASTM E 779:

b. Under ASTM E 779 it is permissible to test using the building's HVAC system. In buildings with multistory HVAC systems and shafts it is permissible to test using the building's mechanical system using CAN/CGSB-149.15-96 Determination of the Overall Envelope Airtightness of Buildings by the Fan Pressurization Method Using the Building's Air Handling Systems, Canadian General Standards Board, Ottawa.

c. In lieu of the fan pressurization method described in ASTM E 779, a tracer gas test of the building air change rate in accordance with ASTM E 741 is also allowed. The tracer gas test shall be run with building HVAC fans off.

d. Section 8.1 - For purposes of this test, a multizone building shall be configured as a single zone by opening all interior doors, and otherwise connecting the interior spaces as much as possible. It is also allowed to test a smaller section of the building, provided the test area can be isolated from neighboring conditioned zones by balancing the pressure in adjacent conditioned zones to that in the zone being tested. This can be very difficult to do in buildings with multistory shafts and HVAC systems. If a smaller section of the building is tested, provide a drawing showing the zone(s) tested, the pressure boundaries and a diagram of the testing equipment configuration.

e. Section 8.2 - Seal all intentional functional openings such as exhaust and relief louvers, grilles and dryer vents that are not used in the test to introduce air, using plastic sheeting and duct tape or similar materials. All plumbing traps shall be filled with water.

f. Section 8.10 - The test pressure range shall be from 10 Pa to 80 Pa. If approved by the building official, lower test pressures are acceptable, but the upper limit shall not be less than 50 Pa.

g. Section 9.4 - If both pressurization and depressurization are not tested, plot the air leakage against the corrected If both pressurization and depressurization are

h. Section 9.6.4 - If the pressure exponent n is less than 0.5 or greater than 1, corrective work shall be performed to the continuous air barrier and the test shall be rerun.

i. Section 10.4 - Report the air leakage rate normalized in cfm/ft^2 at 0.3 inch w.g. (1.57 psf) over the total area of the building envelope air pressure boundary including the lowest floor, any below-grade walls, above-grade walls, and roof (or ceiling) (including windows and skylights) separating the interior conditioned space from the unconditioned environment.

1314.6.3 Certificate of Occupancy: A final certificate of occupancy shall not be issued for the building, or portion thereof, until such time that the building official determines the building, or portion thereof, has been field tested in accordance with Section 1314.6.2.

SECTION 1320 — PRESCRIPTIVE BUILDING ENVELOPE OPTION

1321 General: This section establishes building envelope design criteria in terms of prescribed requirements for building construction.

1322 Opaque Envelope: Roof/ceilings, opaque exterior walls, opaque doors, floors over unconditioned space, below-grade walls, slab-on-grade floors and radiant floors enclosing conditioned spaces shall be insulated according to Section 1311 and Tables 13-1 or 13-2. Compliance with nominal R-values shall be demonstrated for the thermal resistance of the added insulation in framing cavities and/or insulated sheathing only. Nominal R-values shall not include the thermal transmittance of other building materials or air films.

For metal frame assemblies used in spaces with electric resistance space heat, compliance shall be demonstrated with the component U-factor for the overall assembly based on the assemblies in Chapter 10.

Area-weighted averaging of the R-value is not allowed. When showing compliance with R-values, the minimum insulation R-value for all areas of the component shall comply with Table 13-1 or 13-2. When calculating compliance using U-factors, area-weighted averaging is allowed. Where insulation is tapered (e.g., roofs), separate assembly U-factors shall be calculated for each four-foot section of tapered insulation.

EXCEPTION: Opaque smoke vents are not required to meet insulation requirements.

1323 Glazing: Glazing shall comply with Section 1312 and Tables 13-1 or 13-2. All glazing shall be, at a minimum, double glazing. In addition, all glazing assemblies shall have at least one low-emissivity coating unless the glazing assembly has an overall U-factor that complies with the values in Table 13-1 or 13-2.

EXCEPTIONS: 1. Vertical glazing located on the display side of the street level story of a retail occupancy provided the glazing

a. (i) is double-glazed with a minimum 1/2 inch airspace and with a low-e coating having a maximum emittance of e-0.10 in a nonmetal frame or a metal frame having a thermal break (as defined in footnote 2 to Table 10-6B); or

(ii) has an area weighted U-factor of 0.50 or less (U-factor calculations shall use overall assembly U-factors. When this exception is used, there are no SHGC requirements); and

b. does not exceed 75 % of the gross exterior wall area of the display side of the street level story, measured from the top of the finished floor at street level. However, if the display side of the street level story exceeds 20 feet in height, then this exception may only be used for the first 20 feet of that story.

When this exception is utilized, separate calculations shall be performed for these sections of the building envelope and these values shall not be averaged with any others for compliance purposes. The 75% area may be exceeded on the street level, if the additional glass area is provided from allowances from other areas of the building.

2. Single glazing for security purposes and vestibules and revolving doors shall be included in the percentage of the total glazing area, U-factor calculation and SHGC as allowed in the Tables 13-1 or 13-2. The maximum area allowed for the total of all single glazing is 1% of the gross exterior wall area.

1323.1 Area: The percentage of total glazing (vertical and overhead) area relative to the gross exterior wall area shall not be greater than the appropriate value from Tables 13-1 or 13-2 for the vertical glazing U-factor, overhead glazing U-factor and solar heat gain coefficient selected.

1323.2 U-Factor: The area-weighted average U-factor of vertical glazing shall not be greater than that specified in Tables 13-1 or 13-2 for the appropriate area and solar heat gain coefficient. The area-weighted average U-factor of overhead glazing shall not be greater than that specified in Tables 13-1 or 13-2 for the appropriate area and solar heat gain coefficient. U-factors for glazing shall be determined in accordance with Section 1312.

1323.3 Solar Heat Gain Coefficient: The area-weighted average solar heat gain coefficient of all glazing shall not be greater than that specified in Tables 13-1 or 13-2 for the appropriate area and U-factor.

EXCEPTIONS: 1. Glazing separating conditioned space from semi-heated space or unconditioned space.

2. Vertical glazing which is oriented within 45 degrees of north shall be allowed to have a maximum solar heat gain coefficient SHGC-0.05 above that required in Tables 13-1 and 13-2. When this exception is utilized, separate calculations shall be performed for these sections of the building envelope and these values shall not be averaged with any others for compliance purposes.

3. For demonstrating compliance for vertical glazing for the first SHGC option in Tables 13-1 and 13-2 only, the SHGC in the proposed building shall be allowed to be reduced by using the multipliers in the table below for each glazing product shaded by permanent projections that will last as long as the building itself.

Projection Factor	SHGC Multiplier (All Orientations Except North-Oriented)	SHGC Multiplier (North-Oriented)
0 - 0.10	1.00	1.00
<0.10 - 0.20	0.91	0.95
<0.20 - 0.30	0.82	0.91
<0.30 - 0.40	0.74	0.87
<0.40 - 0.50	0.67	0.84
<0.50 - 0.60	0.61	0.81
<0.60 - 0.70	0.56	0.78
<0.70 - 0.80	0.51	0.76
<0.80 - 0.90	0.47	0.75
<0.90 - 1.00	0.44	0.73

Projection factor (PF) is the ratio of the horizontal depth of the external shading projection (A) divided by the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the farthest point of the external shading projection (B), in consistent units. (See Figure 13B.)

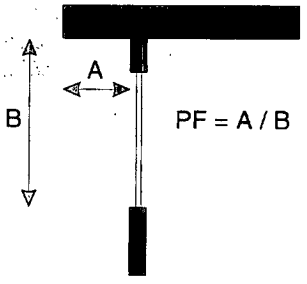

FIGURE 13B

SECTION 1330 — COMPONENT PERFORMANCE BUILDING ENVELOPE OPTION

1331 General: Buildings or structures whose design heat loss rate (UA_p) and solar heat gain coefficient rate (SHGC * A_p) are less than or equal to the target heat loss rate (UA_t) and solar heat gain coefficient rate (SHGC * A_t) shall be considered in compliance with this section. The stated U-factor, F-factor or allowable area of any component assembly, listed in Tables 13-1 or 13-2, such as roof/ceiling, opaque wall, opaque door, glazing, floor over conditioned space, slab-on-grade floor, radiant floor or opaque floor may be increased and the U-factor or F-factor for other components decreased, provided that the total heat gain or loss for the entire building envelope does not exceed the total resulting from compliance to the U-factors, F-factors or allowable areas specified in this section.

EXCEPTION: Compliance is also allowed to be shown using RS-32 for Climate Zone 1 except for buildings containing attic roofs, wood framed walls or vertical fenestration with nonmetal frames, or for Group R occupancies..

1332 Component U-Factors: The U-factors for typical construction assemblies are included in Chapter 10. These values shall be used for all calculations. Where proposed construction assemblies are not represented in Chapter 10, values shall be calculated in accordance with Chapters 16 through 18 and 25 through 27 in Standard RS-1 listed in Chapter 7, using the framing factors listed in Chapter 10. For envelope assemblies containing metal framing, the U-factor shall be determined by one of the following methods:

1. Results of laboratory measurements according to acceptable methods of test.
2. Standard RS-1, listed in Chapter 7, where the metal framing is bonded on one or both sides to a metal skin or covering.
3. The zone method as provided in Chapter 27 of Standard RS-1, listed in Chapter 7.
4. Effective framing/cavity R-values as provided in Table 10-5A.

When return air ceiling plenums are employed, the roof/ceiling assembly shall:

a. For thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly; and

b. For gross area purposes, be based upon the interior face of the upper plenum surface.

1333 UA Calculations: The target UA_t and the proposed UA_p shall be calculated using Equations 13-1 and 13-2 and the corresponding areas and U-factors from Table 13-1 or 13-2. For the target UA_t calculation, the overhead glazing shall be located in roof/ceiling area and the remainder of the glazing allowed per Table 13-1 or 13-2 shall be located in the wall area.

1334 Solar Heat Gain Coefficient Rate Calculations: Solar heat gain coefficient shall comply with Section 1323.3. The target $SHGCA_t$ and the proposed $SHGCA_p$ shall be calculated using Equation 13-3 and 13-4 and the corresponding areas and SHGCs from Table 13-1 or 13-2.

EQUATION 13-1
TARGET UA_t

$$UA_t = U_{rat}A_{rat} + U_{mrt}A_{mrt} + U_{rst}A_{rst} + U_{ort}A_{ort} + U_{ogcort}A_{ogcort} + U_{ogort}A_{ogort} + U_{mwt}A_{mwt} + U_{mbwt}A_{mbwt} + U_{sfwt}A_{sfwt} + U_{wt}A_{wt} + U_{vgt}A_{vgt} + U_{vgmt}A_{vgmt} + U_{vgdt}A_{vgdt} + U_{dt}A_{dt} + U_{fmt}A_{fmt} + U_{fst}A_{fst} + U_{ft}A_{ft} + F_{st}P_{st} + F_{rst}P_{rst}$$

Ua_t = The target combined specific heat transfer of the gross roof/ceiling assembly, exterior wall and floor area.

Where:

U_{radt} = The thermal transmittance value for roofs with the insulation entirely above deck found in Table 13-1 or 13-2.

U_{mrt} = The thermal transmittance value for metal building roofs found in Table 13-1 or 13-2.

U_{rst} = The thermal transmittance value for single rafter roofs found in Table 13-1 or 13-2.

U_{ort} = The thermal transmittance value for attic and other roofs found in Table 13-1 or 13-2.

U_{ogcort} = The thermal transmittance for overhead glazing with curb found in Table 13-1 or 13-2 which corresponds to the proposed total glazing area as a percent of gross exterior wall area.

U_{ogort} = The thermal transmittance for overhead glazing without curb found in Table 13-1 or 13-2 which corresponds to the proposed total glazing area as a percent of gross exterior wall area.

U_{mwt} = The thermal transmittance value for opaque mass walls found in Table 13-1 or 13-2.

U_{mbwt} = The thermal transmittance value for opaque metal building walls found in Table 13-1 or 13-2.

U_{sfwt} = The thermal transmittance value for opaque steel framed walls found in Table 13-1 or 13-2.

U_{wt} = The thermal transmittance value for opaque wood framed and other walls found in Table 13-1 or 13-2.

U_{vgt} = The thermal transmittance value for vertical glazing with nonmetal framing found in Table 13-1 or 13-2 which corresponds to the proposed total glazing area as a percent of gross exterior wall area.

U_{vgmt} = The thermal transmittance value for vertical glazing with metal framing found in Table 13-1 or 13-2 which corresponds to the proposed total glazing area as a percent of gross exterior wall area.

U_{vgdt} = The thermal transmittance value for entrance doors found in Table 13-1 or 13-2 which corresponds to the proposed total glazing area as a percent of gross exterior wall area.

U_{dt} = The thermal transmittance value for opaque doors found in Table 13-1 or 13-2.

U_{fmt} = The thermal transmittance value for mass floors over unconditioned space found in Table 13-1 or 13-2.

U_{fst} = The thermal transmittance value for steel joist floors over unconditioned space found in Table 13-1 or 13-2.

U_{ft} = The thermal transmittance value for wood framed or other floors over unconditioned space found in Table 13-1 or 13-2.

F_{st} = The F-factor for slab-on-grade floors found in Table 13-1 or 13-2.

F_{rst} = The F-factor for radiant slab floors found in Table 13-1 or 13-2.

A_{dt} = The proposed opaque door area, A_d.

A_{fmt} = The proposed mass floor over unconditioned space area, A_{fm}.

A_{fst} = The proposed steel joist floor over unconditioned space area, A_{fs}.

A_{ft} = The proposed wood framed and other floor over unconditioned space area, A_f.

P_{st} = The proposed linear feet of slab-on-grade floor perimeter, P_s.

P_{rst} = The proposed linear feet of radiant slab floor perimeter, P_s.

and;

if the total amount of glazing area as a percent of gross exterior wall area does not exceed the maximum allowed in Table 13-1 or 13-2:

A_{radt} = The proposed roof area with insulation entirely above the deck, A_{rad}.

A_{mrt} = The proposed roof area for metal buildings, A_{mr}.

A_{rst} = The proposed single rafter roof area, A_{rs}.

A_{ort} = The proposed attic and other roof area, A_{or}.

A_{ogcort} = The proposed overhead glazing area with curbs, A_{ogcor}.

A_{ogort} = The proposed overhead glazing without curbs, A_{ogor}.

A_{mwt} = The proposed opaque amass wall area, A_{mw}.

A_{mbwt} = The proposed opaque metal building wall area, A_{mbw}.

A_{sfwt} = The proposed opaque steel framed wall area, A_{sfw}.

A_{wt} = The proposed opaque wood and other wall area, A_{w}.

A_{vgt} = The proposed vertical glazing area with nonmetal framing, A_{vg}.

A_{vgmt} = The proposed vertical glazing area with metal framing, A_{vgm}.

A_{vgdt} = The proposed entrance door area, A_{vgd}.

or;

if the total amount of glazing area as a percent of gross exterior wall area exceeds the maximum allowed in Table 13-1 or 13-2, the area of each fenestration element shall be reduced in the base envelope design by the same percentage and the net area of each wall type adjusted proportionately by the same percentage so that the total overhead and vertical fenestration area is exactly equal to the maximum gross wall area allowed in Table 13-1 or 13-2.

EQUATION 13-2
PROPOSED UA_p

$$UA_p = U_{mr}A_{mr} + U_{ad}A_{ad} + U_{rs}A_{rs} + U_{ra}A_{ra} + U_{ogc}A_{ogc} + U_{og}A_{og} + U_{mw}A_{mw} + U_{mbw}A_{mbw} + U_{sfw}A_{sfw} + U_{wfow}A_{wfow} + U_dA_d + U_{vg}A_{vg} + U_{vgm}A_{vgm} + U_{vgd}A_{vgd} + U_{fm}A_{fm} + U_{fs}A_{fs} + U_{fwo}A_{fwo} + F_sP_s + F_{sr}P_{sr}$$

Where:

UA_p = The combined proposed specific heat transfer of the gross exterior wall, floor and roof/ceiling assembly area.

U_{mr} = The thermal transmittance of the metal building roof area.
A_{mr} = Opaque metal building roof area.

U_{rad} = The thermal transmittance of the roof area where the insulation is entirely above the roof deck.
A_{rad} = Opaque roof area where the insulation is entirely above roof deck.

U_{rs} = The thermal transmittance of the single rafter roof area.
A_{rs} = Opaque single rafter roof area.

U_{ra} = The thermal transmittance of the roof over attic and other roof area.
A_{ra} = Opaque roof over attic and other roof area.

U_{ogc} = The thermal transmittance for the overhead glazing with curbs.
A_{ogc} = Overhead glazing area with curbs.

U_{og} = The thermal transmittance for the overhead glazing without curbs.
A_{og} = Overhead glazing area without curbs.

U_{mw} = The thermal transmittance of the opaque mass wall area.
A_{mw} = Opaque mass wall area (not including opaque doors).

U_{mbw} = The thermal transmittance of the opaque metal building wall area.
A_{mbw} = Opaque metal building wall area (not including opaque doors).

U_{sfw} = The thermal transmittance of the opaque steel framed wall area.
A_{sfw} = Opaque steel framed wall area (not including opaque doors).

U_{wfow} = The thermal transmittance of the opaque wood framed and other wall area.
A_{wfow} = Opaque wood framed and other wall area (not including opaque doors).

U_{vg} = The thermal transmittance of the vertical glazing area with nonmetal framing.
A_{vg} = Vertical glazing area with nonmetal framing.

U_{vgmf} = The thermal transmittance of the vertical glazing area with metal framing.
A_{vgmf} = Vertical glazing area with metal framing.

U_{vg} = The thermal transmittance of the vertical glazing area for entrance doors.
A_{vg} = Vertical glazing area for entrance doors.

U_d = The thermal transmittance value of the opaque door area.
A_d = Opaque door area.

U_{fm} = The thermal transmittance of the mass floor over unconditioned space area.
A_{fm} = Mass floor area over unconditioned space.

U_{fs} = The thermal transmittance of the steel joist floor over unconditioned space area.
A_{fs} = Steel joist floor area over unconditioned space.

U_{fwo} = The thermal transmittance of the wood framed and other floor over unconditioned space area.
A_{fwo} = Wood framed and other floor area over unconditioned space.

F_S = Slab-on-grade floor component F-factor.
P_S = Linear feet of slab-on-grade floor perimeter.

F_{sr} = Radiant floor component F-factor.
P_{sr} = Linear feet of radiant floor perimeter.

⇨ **NOTE:** Where more than one type of wall, window, roof/ceiling, door and skylight is used, the U and A terms for those items shall be expanded into sub-elements as:

$$U_{mw1}A_{mw1}+U_{mw2}A_{mw2}+U_{sfw1}A_{sfw1}+...\text{etc.}$$

EQUATION 13-3
TARGET $SHGCA_t$

$$SHGCA_t = SHGC_t\,(A_{ograt} + A_{ogort} + A_{vgt})$$

Where:

$SHGCA_t$ = The target combined specific heat gain of the target glazing area.

$SHGC_t$ = The solar heat gain coefficient for glazing found in Table 13-1 or 13-2 which corresponds to the proposed total glazing area as a percent of gross exterior wall area, and

A_{ograt}, A_{ogort}, and A_{vgt} are defined under Equation 13-1.

EQUATION 13-4
PROPOSED $SHGCA_p$

$$SHGCA_p = SHGC_{og}A_{og} + SHGC_{vg}A_{vg}$$

Where:

$SHGCA_t$ = The combined proposed specific heat gain of the proposed glazing area.

$SHGC_{og}$ = The solar heat gain coefficient of the overhead glazing.

A_{og}= The overhead glazing area.

$SHGC_{vg}$ = The solar heat gain coefficient of the vertical glazing.

A_{vg} = The vertical glazing area.

TABLE 13-1
BUILDING ENVELOPE REQUIREMENTS FOR CLIMATE ZONE 1

	Nonresidential		Residential, Other than Single-Family	
Opaque Elements	**Assembly Max.**	**Insulation Min. R-Value**	**Assembly Max.**	**Insulation Min. R-Value**
Roofs				
Insulation Entirely above Deck	U-0.034	R-30 c.i.	U-0.031	R-38 c.i.
Metal Building	U-0.031	R-25 + R-11 Ls	U-0.031	R-25 + R-11 Ls
Single-Rafter	U-0.027	R-38	U-0.027	R-38
Attic and Other	U-0.027	R-38 adv or R-49	U-0.027	R-38 adv or R-49
Walls, Above-grade				
Mass[1]	U-0.150	R-5.7 c.i.	U-0.090	R-11.4 c.i.
Metal Building	U-0.064	R-13 + R-7.5 c.i.	U-0.057	R-19 + R-8.5 c.i.
Steel Framed	U-0.064	R-13 + R-7.5c.i.	U-0.057	R-19 + R-8.5 c.i.
Wood Framed and Other	U-0.057	R-21	U-0.057	R-13 + R- 6 c.i.
Wall, Below Grade				
Below Grade Wall		Same as above grade		Same as above grade
Floors				
Mass	U-0.029	R-30 c.i.	U-0.029	R-30 c.i.
Steel Joist	U-0.029	R-38 + R-4 c.i.	U-0.029	R-38 + R-4 c.i.
Wood Framed and Other	U-0.029	R-30	U-0.029	R-30
Slab-On-Grade Floors				
Unheated	F-0.540	R-10 for 24 in. (with thermal break)	F-0.540	R-10 for 24 in. (with thermal break)
Heated	F-0.360	R-10 c.i.(with thermal break)	F-0.360	R-10 c.i. (with thermal break)
Opaque Doors				
Swinging	U-0.600		U-0.400	
Non-Swinging	U-0.600		U-0.400	
Fenestration *0-40% of Wall*	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Fenestration				
Nonmetal framing: all Metal framing: fixed/operable Entrance doors	U-0.32 U-0.40 U-0.60	SHGC-0.40 all, OR SHGC-0.45 all PLUS permanent PF > 0.50 on west, south, and east	U-0.32 U-0.40 U-0.60	
Skylights				
Without curb (i.e. sloped glazing)	U-0.50	SHGC-0.35 all	U-0.50	SHGC-0.35 all
With curb (i.e. individual unit skylights)	U-0.60		U-0.60	

The following definitions apply: c.i. = continuous insulation, Ls = liner system (see definitions)

Footnote

1. Nonresidential walls may be ASTM C90 concrete block walls, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu-in/h•ft^2•°F.

TABLE 13-2
BUILDING ENVELOPE REQUIREMENTS FOR CLIMATE ZONE 2

	Nonresidential		Residential, Other than Single-Family	
Opaque Elements	**Assembly Max.**	**Insulation Min. R-Value**	**Assembly Max.**	**Insulation Min. R-Value**
Roofs				
Insulation Entirely above Deck	U-0.034	R-30 c.i.	U-0.031	R-38 c.i.
Metal Building	U-0.031	R-25 + R-11 Ls	U-0.031	R-25 + R-11 Ls
Single-Rafter	U-0.027	R-38	U-0.027	R-38
Attic and Other	U-0.027	R-38 adv or R-49	U-0.027	R-38 adv or R-49
Walls, Above-grade				
Mass	U-0.123	R-7.6 c.i.	U-0.080	R-13.3 c.i.
Metal Building	U-0.064	R-13 + R-7.5 c.i.	U-0.044	R-19 + R-16 c.i.
Steel Framed	U-0.064	R-13 + R-7.5 c.i.	U-0.044	R-19 + R-14 c.i.
Wood Framed and Other	U-0.051	R-13 + R-7.5 c.i., or R-21 + R-2.5 c.i.	U-0.044	R-21 + R-5 c.i.
Wall, Below Grade				
Below Grade Wall		Same as above grade		Same as above grade
Floors				
Mass	U-0.029	R-30 c.i.	U-0.029	R-30 c.i.
Steel Joist	U-0.029	R-38 + R-4 c.i.	U-0.029	R-38.0 + R-4 c.i.
Wood Framed and Other	U-0.029	R-30	U-0.029	R-30
Slab-On-Grade Floors				
Unheated	F-0.540	R-10 for 24 in. (with thermal break).	F-0.540	R-10 for 24 in. (with thermal break)
Heated	F-0.360	R-10 c.i. (with thermal break)	F-0.360	R-10 c.i. (with thermal break)
Opaque Doors				
Swinging	U-0.600		U-0.400	
Non-Swinging	U-0.600		U-0.400	
Fenestration *0-40% of Wall*	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Fenestration				
Nonmetal framing: all Metal framing: fixed/operable Metal framing, entrance door	U-0.32 U-0.40 U-0.60	SHGC-0.40 all, OR SHGC-0.45 all PLUS permanent PF > 0.50 on west, south, and east	U-0.32 U-0.40 U-0.60	
Skylights				
Without curb (i.e. sloped glazing)	U-0.50	SHGC-0.35 all	U-0.50	SHGC-0.35 all
With curb (i.e. individual unit skylights)	U-0.60		U-0.60	

The following definitions apply: c.i. = continuous insulation, Ls = liner system (see definitions)

CHAPTER 14
MECHANICAL SYSTEMS

1401 Scope: This section covers the determination of requirements, system and component performance, control requirements and duct construction.

1402 Mechanical Ventilation: The minimum requirements for ventilation shall comply with the Washington State Mechanical Code (WAC 51-52).

SECTION 1410 — GENERAL REQUIREMENTS:

The mechanical system shall comply with Sections 1411 through 1416, Sections 1440 through 1443, Sections 1450 through 1454, and with one of the following paths:

a. Simple Systems (Packed Unitary Equipment), Sections 1420 through 1424

b. Complex Systems, Sections 1430 through 1439

c. Systems Analysis. See Section 1141.4

Systems serving cold storage spaces and frozen storage spaces in refrigerated warehouses shall meet the requirements of Section 1416, 1437 and 1460.

FIGURE 14A
MECHANICAL SYSTEMS COMPLIANCE PATH

Section Number	Subject	Simple Systems Path	Complex Systems Path	Systems Analysis Option
1410	General Requirements	X	X	X
1411	HVAC Equipment Performance Requirements	X	X	X
1412	Controls	X	X	X
1413	Air Economizers	X	X	X
1414	Ducting Systems	X	X	X
1415	Piping Systems	X	X	X
1416	Completion Requirements	X	X	X
1420	Simple Systems (Packaged Unitary Equipment)	X		
1421	System Type	X		
1422	Controls	X		
1423	Economizers	X		
1424	Separate Air Distribution Systems	X		
1430	Complex Systems		X	
1431	System Type		X	
1432	Controls		X	
1433	Economizers		X	
1434	Separate Air Distribution Systems		X	
1435	Simultaneous Heating and Cooling		X	
1436	Heat Recovery		X	
1437	Electric Motor Efficiency		X	
1438	Variable Flow Systems		X	
1439	Exhaust Hoods		X	
RS-29	Systems Analysis			X
1440	Domestic Water System	X	X	X
1441	Water Heater Installation	X	X	X
1442	Shut Off Controls	X	X	X
1443	Pipe Insulation	X	X	X
1444	Conservation of Water and Pumping Energy	X	X	X
1445	Heat Recovery for Domestic Water Systems	X	X	X
1446	Domestic Hot Water Meters	X	X	X
1450	Heated Pools	X	X	X
1451	General	X	X	X
1452	Pool Water Heaters	X	X	X
1453	Controls	X	X	X
1454	Pool Covers	X	X	X
1455	Heat Recovery	X	X	X
1460	Cold Storage	X	X	X
1461	Refrigerated Warehouse Heating and Cooling	X	X	X
1462	Underslab Heating	X	X	X
1463	Evaporators	X	X	X
1464	Condensers	X	X	X
1465	Compressors	X	X	X

1411 HVAC Equipment Performance Requirements

1411.1 General: Equipment shall have a minimum performance at the specified rating conditions not less than the values shown in Tables 14-1A through 14-1G. If a nationally recognized certification program exists for a product covered in Tables 14-1A through 14-1G, and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be listed in the certification program.

For equipment not within the scope of the standards in Table 14-1A through 14-1G, this Code does not contain any minimum efficiency requirements. However, for any claims of efficiency, such as for calculations using the RS-29 compliance option, data shall be furnished by the equipment manufacturer consisting of a complete report from a test performed by an independent laboratory accredited by a nationally recognized accreditation organization.

Gas-fired and oil-fired forced air furnaces with input ratings ≥ 225,000 Btu/h (65 kW) and all unit heaters 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.

Chilled water plants and buildings with more than 500 tons total capacity shall not have more than 100 tons provided by air-cooled chillers.

EXCEPTIONS: 1. Where the designer demonstrates that the water quality at the building site fails to meet manufacturer's specifications for the use of water-cooled equipment.

2. Air-cooled chillers with minimum efficiencies at least 10 percent higher than those listed in Table 14-1C.

3. Replacement of existing equipment.

1411.2 Rating Conditions: Cooling equipment shall be rated at AHRI test conditions and procedures when available. Where no applicable procedures exist, data shall be furnished by the equipment manufacturer consisting of a complete report from a test performed by an independent laboratory accredited by a nationally recognized accreditation organization.

1411.2.1 Water-Cooled Centrifugal Water-Chilling Packages—Nonstandard Conditions: Water-cooled centrifugal water-chilling packages that are not designed for operation at AHRI Standard 550/590 test conditions reflected in Table 14-1C (44°F leaving chilled-water temperature and 85°F entering condenser water temperature with 3 gpm/ton condenser water flow) shall have maximum full-load kW/ton and NPLV ratings adjusted using Equation 14-1.

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

- Minimum leaving chilled water temperature: 38°F;
- Maximum condenser entering water temperature: 102°F;
- Condenser water flow: 1 to 6 gpm/ton; and
- $X \geq 39$ and ≤ 60.

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

1411.3 Combination Space and Service Water Heating: For combination space and service water heaters with a principal function of providing space heat, the Combined Annual Efficiency (CAE) may be calculated by using ASHRAE Standard 124-1991. Storage water heaters used in combination space heat and water heat applications shall have either an Energy Factor (EF) or a Combined Annual Efficiency (CAE) of not less than the following:

	Energy Factor (EF)	Combined Annual Efficiency (CAE)
< 50 gallon storage	0.58	0.71
50 to 70 gallon storage	0.57	0.71
> 70 gallon storage	0.55	0.70

1411.4 Packaged Electric Heating and Cooling Equipment: Packaged electric equipment providing both heating and cooling with a total cooling capacity greater than 20,000 Btu/h shall be a heat pump.

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

1411.5 Heating Systems in Unenclosed Spaces: Where comfort heating is provided to unenclosed spaces, only radiant heating systems shall be used unless otherwise approved by the building official.

The heating system shall be controlled by an occupant sensor. An unenclosed space is one that is not substantially surrounded by solid surfaces such as walls, floors, roofs, and openable devices such as doors and operable windows. Warehouses and repair garages are considered enclosed spaces.

1412 Controls

1412.1 Temperature Controls: Each system shall be provided with at least one temperature control device. Each zone shall be controlled by individual thermostatic controls responding to temperature within the zone. At a minimum, each floor of a building shall be considered as a separate zone. Controls on systems required to have economizers and serving single zones shall have multiple cooling stage capability and that activate the economizer when appropriate as the first stage of cooling. See Section 1423 or 1433 for further economizer control requirements.

EQUATION 14-1:

Adjusted maximum full-load kW/ton rating = (Full load kW/ton from Table 14-1C)/K_{adj}

Adjusted maximum NPLV rating = (IPLV from Table 14-1C)/K_{adj}

Where:

K_{adj} = $6.174722 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$

X = DT_{std} + LIFT

DT_{std} = (24 + [full load kW/ton from Table 14-1C] x 6.83)/Flow

Flow = Condenser water flow (gpm)/cooling full load capacity (tons)

LIFT = CEWT - CLWT

CEWT = Full load condenser entering water temperature (F)

CLWT = Full load condenser leaving chilled water temperature (F)

1412.2 Deadband Controls: When used to control both comfort heating and cooling, zone thermostatic controls shall be capable of a deadband of at least 5°F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

EXCEPTIONS: 1. Special occupancy, special usage or code requirements where deadband controls are not appropriate.

2. Thermostats that require manual changeover between heating and cooling modes.

1412.3 Humidity Controls: If a system is equipped with a means for adding moisture, a humidistat shall be provided.

1412.4 Setback and Shut-Off: HVAC systems shall be equipped with automatic controls capable of accomplishing a reduction of energy use through control setback or equipment shutdown during periods of non-use or alternate use of the spaces served by the system. The automatic controls shall:

a. Have a minimum seven-day clock and be capable of being set for seven different day types per week,

b. Be capable of retaining programming and time settings during loss of power for a period of at least ten hours, and

c. Include an accessible manual override, or equivalent function (e.g., telephone interface), that allows temporary operation of the system for up to two hours.

EXCEPTIONS: 1. Systems serving areas which require continuous operation at the same temperature setpoint.

2. Equipment with full load demands of 2 kW (6,826 Btu/h) or less may be controlled by readily accessible manual off-hour controls.

3. Systems controlled by an occupant sensor that is capable of shutting the system off when no occupant is sensed for a period of up to 30 minutes.

4. Systems controlled solely by a manually operated timer capable of operating the system for no more than two hours.

For hotel and motel guest rooms, a minimum of one of the following control technologies shall be required in hotels/motels with over 50 guest rooms such that the space temperature would automatically setback (winter) or set up (summer) by no less than 3°C (5°F) or hotel and motel guest rooms, a minimum of

1. Controls that are activated by the room occupant via the primary room access method - key, card, deadbolt, etc.

2. Occupancy sensor controls that are activated by the occupant's presence in the room.

1412.4.1 Dampers: Outside air intakes, exhaust outlets and relief outlets serving conditioned spaces shall be equipped with motorized dampers which close automatically when the system is off or upon power failure. Return air dampers shall be equipped with motorized dampers. Stair shaft and elevator shaft smoke relief openings shall be equipped with normally open (fails to open upon loss of power) dampers. These dampers shall remain closed until activated by the fire alarm system or other approved smoke detection system.

EXCEPTIONS: 1. Systems serving areas which require continuous operation.

2. Combustion air intakes.

3. Gravity (nonmotorized) relief dampers are acceptable in equipment with less than 5,000 cfm total supply flow when in buildings less than three stories in height.

4. Type 1 Grease hoods exhaust. ⇦

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: 10 cfm/ft^2 of damper area at 1.0 inch w.g.

b. Nonmotorized Dampers: 20 cfm/ft^2 of damper area at 1.0 inch w.g., except that for nonmotorized dampers smaller than 24 inches in either dimension: 40 cfm/ft^2 of damper area at 1.0 inch w.g.

Drawings shall indicate compliance with this section.

1412.4.1.1 Damper Controls: Dampers for outdoor air supply and exhaust shall automatically shut when the systems or spaces served are not in use or during building warm-up, cooldown, and setback. Operation of dampers shall be allowed during ventilation prepurge one hour before expected occupancy and for unoccupied period precooling during the cooling season.

Classrooms, gyms, auditoriums and conference rooms larger than 500 square feet of floor area shall have occupancy sensor control that will either close outside air dampers or turn off serving equipment when the space is unoccupied except where equipped with another means to automatically reduce outside air intake below design rates when spaces are partially occupied.

1412.4.2 Optimum Start Controls: Heating and cooling systems with design supply air capacities exceeding 2,000 cfm shall have optimum start controls. Optimum start controls shall be designed to automatically adjust the start time of an HVAC system each day to bring the space to desired occupied temperature levels immediately before scheduled 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.

1412.5 Heat Pump Controls: Unitary air cooled heat pumps shall include microprocessor controls that minimize supplemental heat usage during start-up, set-up, and defrost conditions. These controls shall anticipate need for heat and use compression heating as the first stage of heat. Controls shall indicate when supplemental heating is being used through visual means (e.g., LED indicators). Heat pumps equipped with supplementary heaters shall be installed with controls that prevent supplemental heater operation above 40°F.

1412.6 Combustion Heating Equipment Controls: Combustion heating equipment with a capacity over 225,000 Btu/h shall have modulating or staged combustion control.

EXCEPTIONS: 1. Boilers. 2. Radiant heaters.

1412.7 Balancing: Each air supply outlet or air or water terminal device shall have a means for balancing, including but not limited to, dampers, temperature and pressure test connections and balancing valves.

1412.8 Ventilation Controls for High-Occupancy Areas: Demand control ventilation (DCV) is required for spaces that are larger than 500 ft^2, have an occupant density for ventilation of greater than 25 people for 1000 ft^2 of floor area (based on the Default Occupant Density column of Table 403.3 of the Washington State Mechanical Code), and are served by systems with one or more of the following:

a. An air-side economizer,
b. Automatic modulating control of the outdoor air damper, or
c. A design outdoor ventilation airflow of all systems serving the space combined greater than 3000 cfm.

EXCEPTIONS: 1.Systems with energy recovery complying with Section 1436.

2. Spaces with a combined design outdoor airflow less than 1000 cfm.

3. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1000 cfm.

1412.9 Enclosed Loading Dock and Parking Garage Exhaust Ventilation System Control: Mechanical ventilation systems for enclosed loading docks and parking garages shall be designed to exhaust the airflow rates (maximum and minimum) determined in accordance with the State Mechanical Code (chapter 51-52 WAC).

Ventilation systems shall be equipped with a control device that operates the system automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices. Each of the following types of controllers shall be capable of shutting off fans or modulating fan speed.

1. Gas sensor controllers used to activate the exhaust ventilation system shall stage or modulate fan speed upon detection of specified gas levels. All equipment used in sensor controlled systems shall be designed for the specific use and installed in accordance with the manufacturer's recommendations. The following are minimum gas sensor system requirements:
   a. Garages and loading docks used predominantly by gasoline-powered vehicles shall be equipped with a controller and a full array of carbon monoxide (CO) sensors set to maintain levels of carbon monoxide below 35 parts per million (ppm). Spacing and location of the sensors shall be installed in accordance with manufacturer recommendations.
   b. Where more than 20 percent of the vehicles using the garage or loading dock are powered by nongasoline fuels, the area exposed to nongasoline fueled vehicle exhaust shall be equipped with a controller and fuel-appropriate sensors. The set-point for the nongasoline sensors shall be no less than the standard used by OSHA for eight hour exposure. The controller shall activate the ventilation system when sensor set-point is reached. Spacing and location of the sensors shall be installed in accordance with manufacturer recommendations.
2. Automatic time clocks used to activate the system shall activate the system during occupied periods. The time clock shall be capable of scheduling multiple start and stop times for each day of the week, varying the daily schedule, and retaining programming for a 10-hour period during loss of power.
3. Occupant detection sensors used to activate the system shall detect entry into the parking garage along both the vehicle and pedestrian pathways.

1412.9.1 System Activation Devices for Enclosed Loading Docks: Ventilation systems for enclosed loading docks shall be activated by one of the following:

1. Gas sensors; or
2. Time clock and a manual over-ride switch located in the dock area that is accessible to persons in the loading dock area.

1412.9.2 System Activation Devices for Enclosed Parking Garages: Ventilation systems for enclosed parking garages shall be activated by gas sensors.

EXCEPTION: A parking garage ventilation system having a total design capacity under 8,000 cfm may use a time clock or occupant sensors.

1413 Economizers

1413.1 Operation: Air economizers shall be capable of automatically modulating outside and return air dampers to provide 100% of the design supply air as outside air to reduce or eliminate the need for mechanical cooling. Systems shall provide a means to relieve excess outdoor air during air economizer operation to prevent overpressurizing the building. Air economizers shall be used for RS-29 analysis base case for all systems without exceptions in Sections 1413, 1423, or 1433. Water economizers, when allowed by Section 1132.2 exception 1 or Section 1433 exceptions 3 and 9, shall be capable of providing the total concurrent cooling load served by the connected terminal equipment lacking airside economizer, at outside air temperatures of 50°F dry-bulb/45°F wet-bulb and below. For this calculation, all factors including solar and internal load shall be the same as those used for peak load calculations, except for the outside temperatures.

1413.2 Documentation: Water economizers plans submitted for approval shall include the following information:

1. Maximum outside air conditions for which economizer is sized to provide full cooling.
2. Design cooling load to be provided by economizer at this outside air condition.
3. Heat rejection and terminal equipment performance data including model number, flow rate, capacity, entering and leaving temperature in full economizer cooling mode.

1413.3 Integrated Operation: The HVAC system and its controls shall allow economizer operation when mechanical cooling is required simultaneously. Air and water economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

EXCEPTIONS: 1. Individual, direct expansion units that have a rated capacity less than 65,000 Btu/h and use nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.

2. Water-cooled water chillers with waterside economizer.

1413.4 Humidification: If an air economizer is required on a cooling system for which humidification equipment is to be provided to maintain minimum indoor humidity levels, then the humidifier shall be of the adiabatic type (direct evaporative media or fog atomization type).

EXCEPTIONS: 1. Health care facilities where WAC 246-320-525 allows only steam injection humidifiers in ductwork downstream of final filters.

2. Systems with water economizer

3. 100% outside air systems with no provisions for air recirculation to the central supply fan.

4. Nonadiabatic humidifiers cumulatively serving no more than 10% of a building's air economizer capacity as measured in cfm. This refers to the system cfm serving rooms with stand alone or duct mounted humidifiers.

1414 Ducting Systems

1414.1 Duct Sealing and Testing: Duct work and plenums shall be sealed in accordance with Section 1414.1.1. Additionally, ducts shall be tested in accordance with Sections 1414.1.2 and 1414.1.3 as required.

1414.1.1 Sealing: Duct work which is designed to operate at pressures above ½ inch water column static pressure shall be sealed as follows:

1. Static pressure ½ inch to 3 inches: Seal all transverse joints and longitudinal seams. Spiral lock seams in round and flat oval duct work do not require sealing; however, other seams shall be sealed.
2. Static pressure above 3 inches: Seal all transverse joints, longitudinal seams and duct wall penetrations.

All low pressure supply and return air systems not located entirely within the conditioned space, including the unconditioned side of enclosed stud bays or joist cavities/spaces used to transport air, shall be securely fastened and sealed. Duct work shall be sealed using welds, gaskets, mastic, or mastic-plus-embedded-fabric tape. Enclosed stud bays or joist cavities/spaces used to transport air shall be sealed using mastic-plus-embedded-fabric tape, or when drywall is used to enclose the air system, drywall mud and tape. Duct tape is not permitted as a sealant on any ducts.

EXCEPTION: Fibrous glass duct systems installed in accordance with Standard UL 181A and flexible duct systems installed in accordance with Standard UL 181B may use tapes listed for these systems.

1414.1.2 Low Pressure Duct Leak Test: All duct systems shall be sealed to a leakage rate not to exceed 6 percent of the fan flow if the duct system:

1. Is connected to a constant volume, single zone, air conditioner, heat pump or furnace; and
2. Serves less than 5,000 square feet of floor area; and
3. Has more than 25 percent duct surface area located in any unconditioned space.

The leakage rate shall be confirmed through field verification and diagnostic testing, in accordance with SMACNA Duct Leakage Test Procedures - 1985.

1414.1.3 High Pressure Duct Leak Test: Duct work that is designed to operate at static pressures in excess of 3 inches water column shall be leak-tested in accordance with SMACNA Duct Leakage Test Procedures - 1985. Representative sections totaling no less than 25 percent of the total installed duct area for the designated pressure class

shall be tested. Duct systems with pressure ratings in excess of 3 in. w.c. shall be identified on the drawings. The maximum permitted duct leakage shall be:

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

Where:

L_{max} = Maximum permitted leakage in cfm/100 ft2 duct surface area.

C_L = Duct leakage class, cfm/100 ft2 at 1 in. w.c.

C_L = 6 for rectangular sheet metal, rectangular fibrous, and round flexible ducts.

C_L = 3 for round/flat oval sheet metal or fibrous glass ducts.

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

1414.2 Insulation: Ducts and plenums that are constructed and function as part of the building envelope, by separating interior space from exterior space, shall meet all applicable requirements of Chapter 13. These requirements include insulation installation, moisture control, air leakage, and building envelope insulation levels. Unheated equipment rooms with combustion air louvers shall be isolated from the conditioned space by insulating interior surfaces to a minimum of R-11 and any exterior envelope surfaces per Chapter 13. Outside air ducts serving individual supply air units with less than 2,800 cfm of total supply air capacity shall be insulated to a minimum of R-7 and are not considered building envelope. Other outside air duct runs are considered building envelope until they,

1. connect to the heating or cooling equipment, or
2. are isolated from the exterior with an automatic shut-off damper complying with Section 1412.4.1.

Once outside air ducts meet the above listed requirements, any runs within conditioned space shall comply with Table 14-5 requirements.

Other ducts and plenums shall be thermally insulated per Table 14-5.

EXCEPTIONS: 1. Within the HVAC equipment.
2. Exhaust air ducts not subject to condensation.
3. Exposed ductwork within a zone that serves that zone.

1415 Piping Systems

1415.1 Insulation: Piping shall be thermally insulated in accordance with Table 14-6.

EXCEPTION: Piping installed within unitary HVAC equipment.

Cold water pipes outside the conditioned space shall be insulated in accordance with the Washington State Plumbing Code (WAC 51-56).

1416 Commissioning and Completion Requirements

1416.1 General: Drawing notes or specifications shall require commissioning and completion requirements in accordance with this section.

1416.2 Commissioning Scope: Commissioning in compliance with this section and Section 1513.7 shall be required for new systems or modified portions of systems, with a heating capacity of 600K Btu/h or a cooling capacity of 40 tons or more.

1416.2.1 Buildings which require commissioning shall go through a commissioning process that includes as a minimum:

1. Commissioning plan;
2. Systems testing and balancing;
3. HVAC equipment and HVAC controls functional testing;
4. Supporting documentation in the form of operation and maintenance and record documents;
5. Commissioning report.

1416.3 Commissioning Requirements

1416.3.1 Commissioning Plan: Commissioning plan shall include:

1. A general description of the commissioning process activities including the systems to be commissioned;
2. The scope of the commissioning process including systems testing and balancing, functional testing, and supporting documentation;
3. Roles and responsibilities of the commissioning team;
4. A schedule of activities including systems testing and balancing, functional testing, and supporting documentation;
5. Functional test procedures and forms.

1416.3.2 Systems Testing and Balancing

1416.3.2.1 General: All HVAC air and hydronic systems shall be balanced in accordance with generally accepted engineering standards.

1416.3.2.2 Air Systems Balancing: Throttling losses shall be minimized by balancing the systems or adjusting the speed of fans with motors greater than 1 hp.

1416.3.2.3 Hydronic Systems Balancing: Throttling losses shall be minimized by balancing the systems, or trimming the pump impeller or adjusting the pump speed.

EXCEPTIONS: 1. Pumps with pump motors of 10 hp or less.

2. Throttling is an acceptable method of balancing only if the power draw does not exceed that of equivalent system with the impeller trimmed by more than 5 percent.

All hydronic heating or cooling coils with design flow exceeding 20 gpm (76 L/m) shall be equipped with dedicated pressure testing ports to enable testing of pressure drop through the coil. All hydronic heating or cooling systems served by pump(s) exceeding 5 hp (3.7 kW) shall be equipped with accessible pressure testing ports to enable testing supply and return pressure near the end of each major hydronic run.

FIGURE 14B
COMMISSIONING COMPLIANCE CHECKLIST

Project Information	**Project Name:** **Project Address:** **Commissioning Authority:**
Commissioning Plan (Section 1416.3.1)	☐ **Commissioning Plan was used during construction and included items below** • A written schedule including Systems Testing and Balancing, Functional Testing, and Supporting Documentation • Roles and Responsibilities of the commissioning team • Functional Test procedures and forms
Systems Balancing (Section 1416.3.2)	☐ **Systems Balancing has been completed** • Air and Hydronic systems are proportionately balanced in a manner to first minimize throttling losses • Test ports are provided on each pump for measuring pressure across the pump.
Functional Testing (Section 1416.3.3)	☐ **HVAC Systems Functional Testing has been completed** (Section 1416.3.3) HVAC systems have been tested to ensure that equipment, components, and sub-systems are installed, calibrated, adjusted and operate in accordance with approved plans and specifications ☐ **HVAC Controls Functional Testing has been completed** (Section 1416.3.3) HVAC controls have been tested to ensure that control devices are calibrated, adjusted and operate properly. Sequences of operation have been functionally tested to ensure they operate in accordance with approved plans and specifications ☐ **Lighting Controls Functional Testing has been completed** (Section 1513.7) Lighting controls have been tested to ensure that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications
Supporting Documents (Section 1416.3.4)	☐ **Systems documentation, record documents and training have been completed or are scheduled** • System documentation has been provided to the owner or scheduled date: _____ • Record documents have been submitted to owner or scheduled date: _____ • Training has been completed or scheduled date: _____
Commissioning Report (Section 1416.3.5)	☐ **Commissioning Report submitted to Owner and includes items below** • Completed Functional Tests documentation • 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 • Deferred tests, which cannot be performed at the time of report preparation due to climatic conditions or other circumstances beyond control of Commissioning Authority.
Certification	☐ I hereby certify that all requirements for Commissioning have been completed in accordance with Washington State Energy Codes, including all items above. _____ Building Owner or Owner's Representative Date

1416.3.3 Systems, Equipment, and Controls Functional Testing: All HVAC systems, equipment, and controls as well as and lighting controls as specified in Section 1513.7 shall be tested to ensure that control devices, components, equipment and systems are calibrated, adjusted and operate in accordance with sequences of operation prescribed in the construction documents. Written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion. Optional examples of test methods and forms are provided in Reference Standard 34.

1416.3.4 Supporting Documentation: Supporting documentation shall include, as a minimum:

1416.3.4.1 Systems Documentation: Systems documentation shall be in accordance with industry accepted standards and shall include as a minimum:

1. Submittal data stating equipment size and selected options for each piece of equipment.
2. Operation and maintenance manuals for each piece of equipment requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
3. Names and addresses of at least one HVAC service agency.
4. HVAC controls system maintenance and calibration information, including wiring diagrams, schematics, as-built drawings and control sequence descriptions. Desired or field determined set points shall be permanently recorded on control drawings at control devices, or, for digital control systems, in programming comments.
5. Complete written narrative of how each system and piece of equipment is intended to operate including interface with existing equipment or systems (where applicable). Sequence of operation is not acceptable as a narrative for this requirement.

1416.3.4.2 Record Documents: Construction documents shall be updated to convey a record of the alterations to the original design. Such updates shall include updated mechanical, electrical and control drawings red-lined, or redrawn if specified, that show all changes to size, type and location of components, equipment and assemblies.

1416.3.4.3 Systems Operation Training: Training of the maintenance staff for each equipment type and or system shall include as a minimum:

1. Review of systems documentation.
2. Hands-on demonstration of all normal maintenance procedures, normal operating modes, and all emergency shutdown and start-up procedures.
3. Training completion report.

1416.3.5 Commissioning Report: The commissioning report shall be completed and provided to the owner. The commissioning report shall include:

1. Completed Functional Test forms including measurable criteria for test acceptance.
2. Issues log of corrected and uncorrected deficiencies with the anticipated date of correction.
3. Deferred tests, which cannot be performed at the time of report preparation, with anticipated date of completion.
4. Record of progress and completion of operator training.
5. Completed Commissioning Compliance form.

1416.4 Commissioning Compliance Form: A commissioning compliance checklist shall be submitted to the building official upon substantial completion of the building. The checklist shall be completed and signed by the building owner or owner's representative. The building official may require that the Commissioning Compliance form components be submitted to verify compliance with Sections 1416 and 1513.8 requirements. Completion of the Commissioning Compliance Checklist (Figure 14B) is deemed to satisfy this requirement.

SECTION 1420 — SIMPLE SYSTEMS (Packaged Unitary Equipment)

1421 System Type: To qualify as a simple system, systems shall have no active humidification or simultaneous heating and cooling and shall be one of the following:

a. Air cooled, constant volume packaged equipment, which provide heating, cooling or both, and require only external connection to duct work and energy services with cooling capacity of 135,000 Btu/h or less.
b. Air cooled, constant volume split systems, which provide heating, cooling or both, with cooling capacity of 84,000 Btu/h or less.
c. Heating only systems which have a capacity of less than 1,000 cfm or which have a minimum outside air supply of less than 30% of the total air circulation.

The combined airflow rate of all simple systems serving single rooms must be less than 10,000 cfm or they do not qualify as simple systems.

All other systems shall comply with Sections 1430 through 1439.

1422 System Sizing Limits: Installed space heating equipment output shall not exceed 10 Btu/h per square foot of gross conditioned floor area and installed space cooling equipment shall not exceed 15 Btu/h per square foot of gross conditioned floor area. No additional safety factor is allowed.

EXCEPTIONS: 1. For equipment which provides both heating and cooling in one package unit, compliance need only be demonstrated for either the space heating or space cooling system size.

2. Equipment sized in accordance with Section 1431.2.

1423 Controls: In addition to the control requirements in Section 1412, where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling. Systems which provide heating and cooling simultaneously to a zone are prohibited.

1424 Economizers: Air economizers meeting the requirements of Section 1413 shall be provided on all new systems, including those serving computer server rooms, electronic equipment, radio equipment, and telephone switchgear.

EXCEPTION: Equipment complying with one of the exceptions to Section 1433.

1425 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.

SECTION 1430 — COMPLEX SYSTEMS

1431 System Type: All systems not qualifying for Sections 1420 through 1424 (Simple Systems), including field fabricated and constructed of system components, shall comply with Sections 1430 through 1439. Simple systems may also comply with Sections 1430 through 1439.

1431.1 Field-Assembled Equipment and Components: Field-assembled equipment and components from more than one manufacturer shall show compliance with this section and Section 1411 through calculations of total on-site energy input and output. The combined component efficiencies as measured per Section 1411.2, shall be in compliance with the requirements of Section 1411.1.

Total on-site energy input to the equipment shall be determined by combining the energy inputs to all components, elements and accessories such as compressors, internal circulating pumps, purge devices, viscosity control heaters and controls.

1431.2 System Sizing Limits: Heating and cooling design loads for the purpose of sizing systems shall be determined in accordance with one of the procedures described in Chapter 29 of Standard RS-1 listed in Chapter 7 or an equivalent computation procedure. For interior temperatures, 70°F shall be used for heating and 75°F for cooling, except where different values are specified in the Washington Administrative Code (WAC).

Building mechanical systems for all buildings which provide space heating and/or space cooling shall be sized no greater than 150 percent of the design load as calculated above, except that cooling towers shall comply with the sizing requirements in Section 1411.1. No additional safety factor is allowed.

For buildings with a total equipment cooling capacity of 300 tons and above, the equipment shall comply with one of the following:

1. No one unit shall have a cooling capacity of more than 2/3 of the total installed cooling equipment capacity;
2. The equipment shall have a variable speed drive; or
3. The equipment shall have multiple compressors.

EXCEPTIONS: The following limited exemptions from the sizing limit shall be allowed, however, in all cases heating and/or cooling design load calculations shall be submitted.

1. For a single piece of equipment which has both heating and cooling capability, only one function, either the heating or the cooling, need meet the requirements of this section. Capacity for the other function shall be, within available equipment options, the smallest size necessary to meet the load.

2. Stand-by equipment may be installed if controls and devices are provided which allow redundant equipment to operate automatically only when the primary equipment is not operating.

3. Multiple units of the same equipment type, such as multiple chillers and boilers, with combined capacities exceeding the design load, or a single unit that is capable of modulating to a part-load capacity of 50 percent of the load or less, may be specified to operate concurrently only if controls are provided that sequence or otherwise optimally control the operation of each unit based on load.

4. Installed space heating equipment output that does not exceed 10 Btu/h per square foot of gross conditioned floor area and installed space cooling equipment output that does not exceed 15 Btu/h per square foot of gross conditioned floor area. No additional safety factor is allowed.

1432 Controls

1432.1 Setback and Shut-Off: Systems that serve zones with different uses, as defined in Table 15-1,

1. shall be served by separate systems, or
2. shall include isolation devices and controls to shut-off or set back the supply of heating and cooling to each zone independently.

EXCEPTION: Isolation or separate systems are not required for zones expected to operate continuously or expected to be inoperative only when all other zones are inoperative.

1432.2 Systems Temperature Reset Controls

1432.2.1 Air Systems for Multiple Zones: Systems supplying heated or cooled air to multiple zones shall include controls which automatically reset supply air temperatures by representative building loads. Temperature shall be reset by at least 25% of the design supply-air-to-room-air temperature difference. Interior zones without an exterior wall load impact and high occupancy areas (per Section 1412.8) shall have maximum airflow sized to meet typical cooling loads with the higher reset air temperature.

EXCEPTIONS: 1. Where specified humidity levels are required to satisfy process needs, such as computer rooms or museums.

2. Systems that prevent reheating, recooling or mixing of heated and cooled air supply.

3. 75 percent of the energy for reheating is from site-recovered or site solar energy sources.

4. Zones with peak supply air quantities of 300 cfm or less.

5. Dedicated outdoor air systems less than 5000 cfm with separate thermal controls.

1432.2.2 Hydronic Systems: Systems with a design capacity of 300,000 Btu/h or greater supplying heated or mechanically refrigerated water shall include controls which automatically reset supply water temperatures by representative building loads or by outside air temperature. Temperature shall be reset by at least 25% of the design supply-to-return water temperature differences.

⇨ **EXCEPTIONS:** 1. Steam boilers.

2. Systems that provide heating with 100°F or lower supply temperature (e.g., water source heat pump loops).

To limit the heat loss from the heat rejection device (cooling tower), for hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection (e.g., cooling tower):

a. If a closed-circuit tower (fluid cooler) is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower (for freeze protection), or low leakage positive closure dampers shall be provided.

b. 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.

c. If an open-circuit tower is used in conjunction with a separate heat exchanger to isolate the tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

For hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection (e.g., cooling tower) and having a total pump system power exceeding 10 hp, each hydronic heat pump shall have:

a. A two-position two-way (but not three-way) valve, or

b. A variable head pressure two-way (water regulating) control valve or pump.

For the purposes of this section, pump system power is the sum of the nominal power demand (i.e., nameplate horsepower at nominal motor efficiency) of motors of all pumps that are required to operate at design conditions to supply fluid from the heating or cooling source to all heat transfer devices (e.g., coils, heat exchanger) and return it to the source. This converts the system into a variable flow system and, as such, the primary circulation pumps shall comply with the variable flow requirements in Section 1438.

1432.3 Hydronic System Valves and Piping

1432.3.1 Hydronic Flow Criteria: HVAC chilled water, condenser water, and hot water pumping shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to no more than the larger of 50 percent or less of the design flow rate, or the minimum flow required by the equipment manufacturer for proper operation of equipment served by the system.

EXCEPTIONS: 1. Heating, chilled, and heat pump water systems that include three or fewer control valves and have a total pump system power less than or equal to 3 hp (2.2 kW).

2. Systems having a total pump system power less than or equal to 1-1/2 hp (1.1 kW).

3. Condenser water systems for chillers.

1432.3.1.1 Variable Flow Controls: Individual pumps requiring variable speed control per Section 1438 shall be controlled in one of the following manners:

1. For systems having a combined pump motor horsepower less than or equal to 20 hp (15 kW) and without direct digital control of individual coils, pump speed shall be a function of either:
   a. Required differential pressure; or
   b. Reset directly based on zone hydronic demand, or other zone load indicators; or
   c. Reset directly based on pump power and pump differential pressure.
2. For systems having a combined pump motor horsepower that exceeds 20 hp (15 kW) or smaller systems with direct digital control, pump speed shall be a function of either:
   a. The static pressure set point as reset based on the valve requiring the most pressure; or
   b. Directly controlled based on zone hydronic demand.

1432.3.2 Heat Rejection Device Isolation: To limit the heat loss from the heat rejection device (cooling tower), for hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection (e.g., cooling tower):

a. If a closed-circuit tower (fluid cooler) is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower (for freeze protection), or low leakage positive closure dampers shall be provided.

b. 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.

c. If an open-circuit tower is used in conjunction with a separate heat exchanger to isolate the tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

1432.3.3 Hydronic Heat Pump Isolation: For hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection (e.g., cooling tower) and having a total pump system power exceeding 10 hp, each hydronic heat pump shall have:

a. A two-position two-way (but not three-way) valve; or

b. A variable head pressure two-way (water regulating) control valve or pump.

For the purposes of this section, pump system power is the sum of the nominal power demand (i.e., nameplate horsepower at nominal motor efficiency) of motors of all pumps that are required to operate at design conditions to supply fluid from the heating or cooling source to all heat transfer devices (e.g., coils, heat exchanger) and return it to

the source. This converts the system into a variable flow system and, as such, the primary circulation pumps shall comply with the variable flow requirements in Section 1438.

1432.3.4 Chiller Isolation: When a chilled water plant includes more than one chiller, provisions shall be made so that flow through any chiller is automatically shut off when that chiller is shut off while still maintaining flow through other operating chiller(s). Chillers that are piped in series for the purpose of increased temperature differential shall be considered as one chiller.

EXCEPTION: Chillers that are piped in series for the purpose of increased temperature differential.

1432.3.5 Boiler Isolation: When a hot water plant includes more than one boiler, provisions shall be made so that flow through any boiler is automatically shut off when that boiler is shut off while still maintaining flow through other operating boiler(s).

1432.4 Direct Digital Control System Capabilities: All complex systems equipped with direct digital control (DDC) systems and all buildings with total cooling capacity exceeding 780,000 Btu/hr (2,662 kW) shall have the following capability:

a. Trending: All control system input and output points shall be accessible and programmed for trending, and a graphic trending package shall be provided with the control system.

b. Demand Response Setpoint Adjustment: Control logic shall increase the cooling zone set points by at least 2°F (1°C) and reduce the heating zone set points by at least 2°F (1°C) when activated by a demand response signal. The demand response signal shall be a binary input to the control system or other interface approved by the serving electric utility.

1432.5 Variable Air Volume System Static Pressure Reset Controls: The static pressure set point shall be reset to the lowest point possible while still providing the required air flow to the zones with the greatest demand.

EXCEPTION: Systems where fan speed is reset directly based on zone airflows or other zone load indicators.

1433 Economizers: Air economizers meeting the requirements of Section 1413 shall be provided on all new systems including those serving computer server rooms, electronic equipment, radio equipment, telephone switchgear.

EXCEPTIONS: 1. Qualifying small equipment: This exception shall not be used for unitary cooling equipment installed outdoors or in a mechanical room adjacent to the outdoors. This exception is allowed to be used for other cooling units and split systems with a total cooling capacity rated in accordance with Section 1411.2 of less than 33,000 Btu/h (hereafter referred to as qualifying small systems) provided that these are high-efficiency cooling equipment with SEER and EER values more than 15% higher than minimum efficiencies listed in Tables 14-1A, 14-1B and 14-1D, in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. The total capacity of all qualifying small equipment without economizers shall not exceed 72,000 Btu/h per building, or 5% of its air economizer capacity, whichever is greater. That portion of the equipment serving Group R Occupancy is not included in determining the total capacity of all units without economizers in a building. Redundant units are not counted in the capacity limitations. This exception shall not be used for the shell-and-core permit or for the initial tenant improvement or for RS-29 analysis.

2. Chilled water terminal units connected to systems with chilled water generation equipment with IPLV values more than 25% higher than minimum part load efficiencies listed in Table 14-1C, in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. The total capacity of all systems without economizers shall not exceed 480,000 Btu/h per building, or 20% of its air economizer capacity, whichever is greater. That portion of the equipment serving Group R Occupancy is not included in determining the total capacity of all units without economizers in a building. This exception shall not be used for the shell-and-core permit or for the initial tenant improvement or for RS-29 analysis.

3. Water-cooled refrigeration equipment serving chilled beams and chilled ceiling space cooling systems only which are provided with a water economizer meeting the requirements of Section 1413. Water economizer capacity per building shall not exceed 500 tons. This exception shall not be used for RS-29 analysis.

4. Systems for which at least 75% of the annual energy used for mechanical cooling is provided from site-recovery or site-solar energy source.

5. Systems where special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants, makes an air economizer infeasible.

6. Systems with dehumidification that affect other systems so as to increase the overall building energy consumption. New humidification equipment shall comply with Section 1413.4.

7. Systems complying with all of the following criteria:

a. Consist of multiple water source heat pumps connected to a common water loop;

b. Have a minimum of 60% air economizer;

c. Have water source heat pumps with an EER at least 15% higher for cooling and a COP at least 15% higher for heating than that specified in Section 1411;

d. Where provided, have a central boiler or furnace efficiency of 90% minimum for units up to 199,000 Btu/h; and

e. Provide heat recovery with a minimum 50% heat recovery effectiveness as defined in Section 1436 to preheat the outside air supply.

8. For Group R Occupancy, cooling units installed outdoors or in a mechanical room adjacent to outdoors with a total cooling capacity less than 20,000 Btu/h and other cooling units with a total cooling capacity less than 54,000 Btu/h provided that these are high-efficiency cooling equipment with SEER and EER values more than 15% higher than minimum efficiencies listed in Tables 14-1A, 14-1B and 14-1D, in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. For split systems, compliance is based on the cooling capacity of individual fan coil units.

9. Equipment used to cool any dedicated server room, electronic equipment room or telecom switch room provided that they completely comply with option 9a, 9b, or 9c in the table below. The total capacity of all systems without economizers shall not exceed 240,000 Btu/h per building or 10% of its air economizer capacity, whichever is greater. This exception shall not be used for RS-29 analysis.

	Equipment Type	Higher Equipment Efficiency	Part-Load Control	Economizer
Option 9a	Tables 14-1A and 14-1B[a]	+15%[b]	Required over 85,000 Btu/h[c]	None required
Option 9b	Tables 14-1A and 14-1B[a]	+5%[d]	Required over 85,000 Btu/h[c]	Waterside Economizer
Option 9c	ASHRAE Standard 127[f]	+0%[g]	Required over 85,000 Btu/h[c]	Waterside Economizer

Notes for Exception 9:

a. For a system where all of the cooling equipment is subject to the AHRI standards listed in Tables 14-1A and 14-1B, the system shall comply with all of the following (note that if the system contains any cooling equipment that exceeds the capacity limits in Table 14-1A or 14-1B, or if the system contains any cooling equipment that is not included in Table 14-1A or 14-1B, then the system is not allowed to use this option).

b. The cooling equipment shall have an EER value and an IPLV value that is a minimum of 15% greater than the value listed in Tables 14-1A and 14-1B (1.15 x values in Tables 14-1A and 14-1B).

c. For units with a total cooling capacity over 85,000 Btu/h, the system shall utilize part-load capacity control schemes that are able to modulate to a part-load capacity of 50% of the load or less that results in the compressor operating at the same or higher EER at part loads than at full load (e.g., minimum of two-stages of compressor unloading such as cylinder unloading, two-stage scrolls, dual tandem scrolls, but hot gas bypass is not credited as a compressor unloading system).

d. The cooling equipment shall have an EER value and an IPLV value that is a minimum of 5% greater than the value listed in Tables 14-1A and 14-1B (1.05 x values in Tables 14-1A and 14-1B).

e. The system shall include a water economizer in lieu of air economizer. Water economizers shall be capable of providing the total concurrent cooling load served by the connected terminal equipment lacking airside economizer, at outside air temperatures of 50°F dry-bulb/45°F wet-bulb and below. For this calculation, all factors including solar and internal load shall be the same as those used for peak load calculations, except for the outside temperatures. The equipment shall be served by a dedicated condenser water system unless a nondedicated condenser water system exists that can provide appropriate water temperatures during hours when waterside economizer cooling is available.

f. For a system where all cooling equipment is subject to ASHRAE Standard 127-2007.

g. The cooling equipment subject to the ASHRAE Standard 127-2007 shall have an EER value and an IPLV value that is equal or greater than the value listed in Tables 14-1A and 14-1B when determined in accordance with the rating conditions ASHRAE Standard 127-2007 (i.e., not the rating conditions in AHRI Standard 210/240 or 340/360). This information shall be provided by an independent third party.

10. Variable refrigerant flow (VRF) systems, multiple-zone split-system heat pumps, consisting of multiple, individually metered indoor units with multi-speed fan motors, served on a single common refrigeration circuit with an exterior reverse-cycle heat pump with variable speed compressor(s) and variable speed condenser fan(s). These systems shall also be capable of providing simultaneous heating and cooling operation, where recovered energy from the indoor units operating in one mode can be transferred to one or more indoor units operating in the other mode, and shall serve at least 20%internal (no perimeter wall within 12') and 20% perimeter zones (as determined by conditioned floor area) and the outdoor unit shall be at least 65,000 Btu/h in total capacity. Systems utilizing this exception shall have 50% heat recovery effectiveness on the outside air. For the purposes of this exception, dedicated server rooms, electronic equipment rooms or telecom switch rooms are not considered perimeter zones. This exception shall be limited to buildings of 60,000 square feet and less.

1434 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 that 25% of the total system supply air, or
2. The total conditioned floor area of the zones is less than 1,000 square feet.

1435 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, ground water, or by mechanical refrigeration.

d. Other simultaneous operation of heating and cooling systems to the same zone.

e. Reheating for humidity control.

EXCEPTIONS: 1. Variable air volume (VAV) systems which, during periods of occupancy, are designed and controlled:

1.1 To reduce the primary air supply to each zone to a minimum air volume when the zone temperature is in a 5°F (3°C) zone temperature dead band after cooling is no longer required and before reheating, recooling or mixing takes placed. This minimum volume shall be no greater than the larger of following:

1.1.1 20% of the peak supply volume; or

1.1.2 The volume of outdoor air required to meet zone ventilation requirements, unless increasing the volume to critical zones (zones with the highest ratio of outside air to total supply air) beyond the minimum ventilation requirements results in a decrease in overall outside air required by the HVAC system. An increase beyond minimum ventilation rates shall not be applied to more than 20% of the zones with reheat on any one system excluding zones equipped with ventilation controls for high occupancy areas required by Section 1317.2.2.

1.2 So the volume of air that is reheated, recooled, or mixed in peak heating demand shall be less than 50% of the zone design peak supply rate.

1.3 So the airflow between dead band and full heating or full cooling shall be modulated.

1.4 So the control logic of each system shall have means preventing changes in setpoint(s) from inducting simultaneous heating and cooling (including economizer cooling) except for humidity control or zone controls operating as described under exception 1.1.

2. Zones where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that variable air volume systems are impractical, such as some areas of hospitals and laboratories. Systems which use this exception and supply heated or cooled air to multiple zones shall include:

2.1 Controls that automatically reset supply air temperatures by representative building loads or by outside air temperature unless it can be shown that supply air temperature reset increases overall building annual energy costs.

2.2 Variable speed drives for supply and return fans, zone dampers on all zones, specified occupied and unoccupied or low occupancy airflows, and have controls which reduce airflow in response to changes in occupancy levels.

3. 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.

4. Zones where specific humidity levels are required to satisfy process needs, such as computer rooms, museums, surgical suites, and buildings with refrigerating systems, such as supermarkets, refrigerated warehoused and ice arenas.

5. Zones with peak supply air quantity of 300 cfm (142L/s) or less.

6. Three deck multizone systems that mix economizer-cooled (mixed) air with heated or cooled air where the temperature of the economized-cooled air is reset based on weighted zone heating and cooling loads and zone airflow is reduced to a minimum of 20% design airflow or the volume of outdoor air required to meet zone ventilation requirements before mixing is allowed.

1436 Heat Recovery

1436.1 Fan Systems: Fan systems which have a minimum outdoor air capacity of 5,000 cfm or greater shall have a heat recovery system with at least 50% recovery effectiveness. Fifty percent heat recovery effectiveness shall mean an increase in the outside air supply temperature at design heating conditions of one half the difference between the outdoor design air temperature and 65°F. Provisions shall be made to bypass or control the heat recovery system to permit air economizer operation as required by Section 1433. Heat recovery energy may be provided from any site-recovered or site-solar source. Where a single room or space is supplied by multiple units, the aggregate ventilation (cfm) of those units shall be used in applying this requirement.

EXCEPTIONS: These exceptions only apply to the particular exhaust subsystems. The remaining cfm of the main supply system is subject to the energy recovery requirements.

1. Laboratory systems equipped with both variable air volume supply and variable air volume or two-speed exhaust fume hoods provided that an instruction label is placed on the face of the hood that provides the information in Exhibit 14-1.

EXHIBIT 14-1

INSTRUCTIONS TO OPERATOR
To be in compliance with the Energy Code, this fume hood is designed to operate as variable air volume (VAV) by adjusting the sash or controller. Maintain sash in the minimum position during use and close totally when the fume hood is not in use.

2. Systems serving spaces heated to less than 60°F.

3. Systems which can be shown to use as much energy with the addition of heat recovery equipment as without it.

4. Systems exhausting toxic, flammable, paint exhaust or corrosive fumes making the installation of heat recovery equipment impractical.

5. Type I commercial kitchen hoods.

6. Systems that only provide cooling.

7. Cooling only air handling units or air conditioning units where the minimum outdoor air is less than 70% of total supply air.

1436.2 Condensate Systems: On-site steam heating systems shall have condensate water recovery. On-site includes a system that is located within or adjacent to one or more buildings within the boundary of a contiguous area or campus under one ownership and which serves one or more of those buildings.

Buildings using steam generated off-site with steam heating systems which do not have condensate water recovery shall have condensate water recovery.

1436.3 Heat Recovery for Service Water Heating: Condenser water heat recovery systems shall be installed for heating or preheating of service hot water provided all of the following are true:

a. The facility operates 24 hours a day.
b. The total installed heat rejection capacity of the water-cooled systems exceeds 1,500,000 Btu/h of heat rejection.
c. The capacity of service water heating equipment exceeds 250,000 Btu/h.

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

a. 60% of the peak heat rejection load at design conditions; or
b. Preheat of the peak service hot water draw to 85°F; or
c. 50% of the service water heating load.

EXCEPTIONS: 1. Facilities that employ condenser heat recovery for space heating with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.

2. Facilities that provide 60% of their service water heating from site solar or site recovered energy or from other sources.

1436.4 Condenser Heat Recovery: Facilities having food service, meat or deli departments and having 500,000 Btu/h or greater of remote refrigeration condensers shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for service water heating, space heating or for dehumidification reheat. Facilities having a gross conditioned floor area of 40,000 ft^2 or greater and 1,000,000 Btu/h or greater of remote refrigeration shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for service water heating, and either for space heating or for dehumidification reheat for maintaining low space humidity.

1437 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 14-4.

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 1411 and Tables 14-1A through 14-1G 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 be electronically commutated motors, or shall have a minimum motor efficiency of 65% when rated in accordance with NEMA Standard MG-1 at full load rating conditions.

1438 System Criteria: For fans and pumps 7.5 hp and greater including custom and packaged air handlers serving variable air volume fan systems, constant volume fans, heating and cooling hydronic pumping systems, pool and service water pumping systems, domestic water pressure boosting systems, cooling tower fan, and other pumps or fans where variable flows are required, there shall be:

a. Variable speed drives, or
b. Other controls and devices that will result in fan and pump motor demand of no more than 30% of design wattage at 50% of design air volume for fans when static pressure set point equals 1/3 the total design static pressure, and 50% of design water flow for pumps, based on manufacturer's certified test data. Variable inlet vanes, throttling valves (dampers), scroll dampers or bypass circuits shall not be allowed.

EXCEPTION: Variable speed devices are not required for motors that serve:

1. Fans or pumps in packaged equipment where variable speed drives are not available as a factory option from the equipment manufacturer.

2. Fans or pumps that are required to operate only for emergency fire-life-safety events (e.g. stairwell pressurization fans, elevator pressurization fans, fire pumps, etc.).

1438.1 Heat Rejection Equipment: The requirements of this section apply to heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers, and evaporative condensers.

EXCEPTION: Heat rejection devices included as an integral part of equipment listed in Tables 14-1A through 14-1D. Heat rejection equipment shall have a minimum efficiency performance not less than values specified in Table 14-1G. These requirements apply to all propeller, axial fan and centrifugal fan cooling towers. Table 14-1G specifies requirements for air-cooled condensers that are within rating conditions specified within the table.

1438.1.1 Variable Flow Controls: Cooling tower fans 7.5 hp and greater shall have control devices that vary flow by controlling the leaving fluid temperature or condenser temperature/pressure of the heat rejection device.

1438.1.2 Limitation on Centrifugal Fan Cooling Towers: Open cooling towers with a combined rated capacity of 1,100 gpm and greater at 95°F condenser water return, 85°F condenser water supply and 75°F outdoor wet-bulb temperature shall meet the energy efficiency requirement for axial fan open circuit cooling towers.

EXCEPTION: Open circuit cooling towers that are ducted (inlet or discharge) or have external sound attenuation that requires external static pressure capability.

1438.2 Hot Gas Bypass Limitation: Cooling equipment with direct expansion coils rated at greater than 95,000 Btu/h total cooling capacity shall have a minimum of two stages of cooling capacity or capacity modulation other than hot gas bypass that is capable of reducing input and output by at least 50%.

1438.3 Large Volume Fan Systems: Single or multiple fan systems serving a zone or adjacent zones without separating walls with total air flow over 10,000 cfm (3,540 L/s) are required to reduce airflow based on space thermostat heating and cooling demand. A variable speed drive shall reduce airflow to a maximum 75% of peak

airflow or minimum ventilation air requirement as required by Section 403 of the IMC, whichever is greater.

EXCEPTIONS: 1. 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.

2. Dedicated outdoor air supply unit(s) with heat recovery where airflow is equal to the minimum ventilation requirements and other fans cycle off unless heating or cooling is required.

3. An area served by multiple units where designated ventilation units have 50% or less of total area airflow and nonventilation unit fans cycle off when heating or cooling is not required.

1439 Exhaust Systems

1439.1 Kitchen Hoods. Each kitchen area with total exhaust capacity larger than 2,000 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 60°F and (b) uncooled or cooled without the use of mechanical cooling.

EXCEPTION: 1. Where hoods are used to exhaust ventilation air which would otherwise exfiltrate or be exhausted by other fan systems. A detailed accounting of exhaust airflows shall be provided on the plans that accounts for the impact of any required demand controlled ventilation.

2. Certified grease extractor hoods that require a face velocity no greater than 60 fpm.

1439.2 Laboratory Exhaust Systems: Buildings with laboratory exhaust systems having a total exhaust rate greater than 5,000 cfm (2,360 L/s) shall include heat recovery systems to preconditioned makeup air from laboratory exhaust. The heat recovery system shall be capable of increasing the outside air supply temperature at design heating conditions by 25°F (13.9°C) in Climate Zone 1 and 35°F (19.4°C) in Climate Zone 2. A provision shall be made to bypass or control the heat recovery system to permit air economizer operation as required by Section 1433.

EXCEPTIONS: 1. Variable air volume laboratory exhaust and room supply systems capable of reducing exhaust and make-up air volume to 50% or less of design values; or

2. Direct make-up (auxiliary) air supply equal to at least 75% of the exhaust rate, heated no warmer than 2°F (1.1°C) below room set point, cooled to no cooler than 3°F (1.7°C) above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control; or

3. Combined Energy Reduction Method: VAV exhaust and room supply system capable of reducing exhaust and makeup air volumes and a heat recovery system to precondition makeup air from laboratory exhaust that when combined will produce the same energy reduction as achieved by a heat recovery system with a 50% sensible recovery effectiveness as required above. For calculation purposes, the heat recovery component can be assumed to include the maximum design supply airflow rate at design conditions. The combined energy reduction (Q_{ER}) shall meet the following:

$Q_{ER} \geq Q_{MIN}$

$Q_{MIN} = CFM_S \cdot (T_R - T_O) \cdot 1.1 \cdot 0.6$

$Q_{ER} = CFM_S \cdot (T_R - T_O) \cdot 1.1(A+B)/100$

Where:

Q_{MIN} = Energy recovery at 60% sensible effectiveness (Btu/h)

Q_{ER} = Combined energy reduction (Btu/h)

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

T_R = Space return air dry bulb at winter design conditions

T_O = Outdoor air dry bulb at winter design conditions

A = Percentage that the exhaust and makeup air volumes can be reduced from design conditions

B = Percentage sensible heat recovery effectiveness

SECTION 1440 — DOMESTIC WATER SYSTEMS

Service water heating equipment shall comply with the applicable efficiencies in Tables 14-1A through 14-1G.

1441 Water Heater Installation: Electric water heaters in unconditioned spaces or on concrete floors shall be placed on an incompressible, insulated surface with a minimum thermal resistance of R-10.

1442 Shut-Off Controls: Systems designed to maintain usage temperatures in hot water pipes, such as circulating hot water systems or heat traced pipes shall be equipped with automatic time switches or other controls to turn off the system during periods of non-use.

1443 Pipe Insulation: Piping shall be thermally insulated in accordance with Section 1415.1.

1444 Conservation of Water and Pumping Energy: Pumps for all domestic water systems shall comply with Section 1438.

1445 Heat Recovery for Domestic Water Systems: Condenser water heat recovery systems shall be installed for heating or preheating of service hot water provided all of the following are true:

1. The total installed heat rejection capacity of the water-cooled systems exceeds 1,500,000 Btu/h of heat rejection; and
2. The capacity of service water heating equipment exceeds 250,000 Btu/h.

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

1. 60% of the peak heat rejection load at design conditions; or
2. Preheat of the peak service hot water draw to 85°F; or
3. 50% of the service water heating load.

EXCEPTIONS: 1. Facilities that employ condenser heat recovery for space heating with a heat recovery design exceeding 30% of the peak water-cooled condenser load at design conditions.

2. Facilities that provide 60% of their service water heating from site solar or site recovered energy or from other sources.

1446 Domestic Hot Water Meters: Each individual dwelling unit in a Group R-2 Multi-Family residential occupancy with central service shall be provided with a domestic hot water meter to allow for domestic hot water billing based on actual domestic hot water usage.

SECTION 1450 — HEATED POOLS

1451 General: The requirements in this section apply to "general and limited use pools" as defined in the Washington Water Recreation Facilities Regulations (WAC 246-260).

1452 Pool Water Heaters: Heat pump pool heaters shall have a minimum COP of 4.0 determined in accordance with ASHRAE Standard 146, Method of Testing for Rating Pool Heaters. Other pool heating equipment shall comply with the applicable efficiencies in Tables 14-1A through 14-1G.

1453 Controls: All pool heaters shall be equipped with a readily accessible ON/OFF switch to allow shutting off the operation of the heater without adjusting the thermostat setting. Controls shall be provided to allow the water temperature to be regulated from the maximum design temperature down to 65°F.

1454 Pool Covers and Insulation: Heated pools shall be equipped with a vapor retardant pool cover on or at the water surface. Pools heated to more than 90°F shall have a pool cover with a minimum insulation value of R-12, and the sides and bottom of the pool shall also have a minimum insulation value of R-12.

1455 Heat Recovery: Heated indoor swimming pools, spas or hot tubs with water surface area greater than 200 square feet shall provide for energy conservation by an exhaust air heat recovery system that heats ventilation air, pool water or domestic hot water. The heat recovery system shall be capable of decreasing the exhaust air temperature at design heating conditions (80°F indoor) by 36°F (10°C) in Climate Zone 1 and 48°F (26.7°C) in Climate Zone 2.

EXCEPTION: Pools, spas or hot tubs that include system(s) that provide equivalent recovered energy on an annual basis through one of the following methods:

1. Renewable energy;
2. Dehumidification heat recovery;
3. Waste heat recovery; or
4. A combination of these system(s) sources capable of providing at least 70% of the heating energy required over an operating season.

SECTION 1460 — COLD STORAGE

1461 Refrigerated Warehouse Heating and Cooling: Heating and cooling systems that supply cold storage spaces and frozen storage spaces in refrigerated warehouses shall meet the requirements of this section.

1462 Underslab Heating: Electric resistance heat shall not be used for the purposes of underslab heating.

EXCEPTION: Underslab heating systems controlled such that the electric resistance heat is thermostatically controlled and provided with a digital input or other interface approved by the local utility that allows heat to be disabled during on-peak periods defined by the local electric utility.

1463 Evaporators: Fan-powered evaporators used in coolers and freezers shall conform to the following:

1. Single phase fan motors less than 1 hp and less than 460 volts shall be electronically commutated motors.
2. Evaporator fans shall be variable speed and the speed shall be controlled in response to space conditions.

EXCEPTION: Evaporators served by a single compressor without unloading capability.

1464 Condensers: Fan-powered condensers shall conform to the following:

1. Condensers for systems utilizing ammonia shall be evaporatively cooled.
2. Condensing temperatures for evaporative condensers under design conditions, including, but not limited to, condensers served by cooling towers shall be less than or equal to:
   a. The design wetbulb temperature plus 20°F in locations where the design wetbulb temperature is less than or equal to 76°F;
   b. The design wetbulb temperature plus 19°F in locations where the design wetbulb temperature is between 76°F and 78°F; or
   c. The design wetbulb temperature plus 18°F in locations where the design wetbulb temperature is greater than or equal to 78°F.
3. Condensing temperatures for air-cooled condensers under design conditions shall be less than or equal to the design drybulb temperature plus 10°F for systems serving frozen storage and shall be less than or equal to the design drybulb temperature plus 15°F for systems serving cold storage.

   EXCEPTION: Unitary condensing units.
4. All condenser fans for evaporative condensers shall be continuously variable speed, and the condensing temperature control system shall control the speed of all condenser fans serving a common condenser loop in unison. The minimum condensing temperature setpoint shall be less than or equal to 70°F.
5. All condenser fans for air-cooled condensers shall be continuously variable speed and the condensing temperature or pressure control system shall control the speed of all condenser fans serving a common condenser loop in unison. The minimum condensing temperature setpoint shall be less than or equal to 70°F, or reset in response to ambient drybulb temperature ore refrigeration system load.
6. All single phase condenser fan motors less than 1 hp and less than 460 volts shall be either permanent split capacitor or electronically commutated motors.

1465 Compressors: Compressor systems utilized in refrigerated warehouses shall conform to the following:

1. Compressors shall be designed to operate at a minimum condensing temperature of 70°F or less.
2. The compressor speed of a screw compressor greater than 50 hp shall be controllable in response to the refrigeration load or the input power to the compressor shall be controlled to be less than or equal to 60% of full load input power when operated at 50% of full refrigeration capacity.

   EXCEPTION: Refrigeration plants with more than one dedicated compressor per suction group.

TABLE 14-1A
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Conditioners, Air Cooled	< 65,000 Btu/h[d]	Split System	13.0 SEER	AHRI 210/240
		Single Package	13.0 SEER	
	≥65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package	11.2 EER[c] 11.4 IEER[c]	AHRI 340/360
	≥135,000 Btu/h and < 240,000 Btu/h	Split System and Single Package	11.0 EER[c] 11.2 IEER[c]	
	≥ 240,000 Btu/h and <760,000 Btu/h	Split System and Single Package	10.0 EER[c] 10.1 IEER[c]	
	≥760,000 Btu/h	Split System and Single Package	9.7 EER[c] 9.8 IEER[c]	
Through-the-Wall, Air Cooled	<30,000 Btu/h[d]	Split System	12.0 SEER	AHRI 210/240
		Single Package	12.0 SEER	
Small-Duct High-Velocity, Air Cooled	<65,000 Btu/h[d]	Split System	10.0 SEER	AHRI 210/240
Air Conditioners, Water and Evaporatively Cooled	< 65,000 Btu/h	Split System and Single Package	12.1 EER[c] 12.3 IEER[c]	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package	11.5 EER[c] 11.7 IEER[c]	AHRI 340/360
	≥135,000 Btu/h and ≤240,000 Btu/h	Split System and Single Package	11.0 EER[c] 11.2 IEER[c]	
	> 240,000 Btu/h	Split System and Single Package	11.0 EER[c] 11.1 IEER[c]	
Condensing Units, Air Cooled	≥135,000 Btu/h		10.1 EER 11.2 IPLV	AHRI 365
Condensing Units, Water or Evaporatively Cooled	≥135,000 Btu/h		13.1 EER 13.1 IPLV	

[a] Reserved.
[b] IPLVs are only applicable to equipment with capacity modulation.
[c] Deduct 0.2 from the required EERs and IEERs for units with a heating section other than electric resistance heat.
[d] Applies to all units, including single-phase and three-phase. For single-phase air cooled air-conditioners < 65,000 Btu/h, SEER values are those set by NAECA.
[e] Reserved.

TABLE 14-1B
UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Cooled, (Cooling Mode)	< 65,000 Btu/h[d]	Split System	13.0 SEER	AHRI 210/240
		Single Package	13.0 SEER	
	≥65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package[e]	11.0 EER[c] 11.2 IEER[c]	AHRI 340/360
	≥135,000 Btu/h and <240,000 Btu/h	Split System and Single Package	10.6 EER[c] 10.7 IEER[c]	
	≥240,000 Btu/h	Split System and Single Package	9.5 EER[c] 9.6 IEER[c]	
Through-the-Wall (Air Cooled, Cooling Mode)	<30,000 Btu/h[d]	Split System	12.0 SEER	AHRI 210/240
		Single Package	12.0 SEER	
Small-Duct High-Velocity (Air Cooled, Cooling Mode)	< 65,000 Btu/h[d]	Split System	10.0 SEER	AHRI 210/240
Water-Source (Cooling Mode)	< 17,000 Btu/h	86°F Entering Water	11.2 EER	AHRI/ISO-13256-1
	≥ 17,000 Btu/h and <65,000 Btu/h	86°F Entering Water	12.0 EER	AHRI/ISO-13256-1
	≥65,000 Btu/h and < 135,000 Btu/h	86°F Entering Water	12.0 EER	AHRI/ISO-13256-1
Groundwater-Source (Cooling Mode)	< 135,000 Btu/h	59°F Entering Water	16.2 EER	AHRI/ISO-13256-1
Ground Source (Cooling Mode)	< 135,000 Btu/h	77°F Entering Water	13.4 EER	AHRI/ISO-13256-1
Air Cooled (Heating Mode)	< 65,000 Btu/h[d] (Cooling Capacity)	Split System	7.7 HSPF[e]	AHRI 210/240
		Single Package	7.7 HSPF	
	≥65,000 Btu/h and < 135,000 Btu/h (Cooling Capacity)	47°F db/43°F wb Outdoor Air	3.3 COP	
		17°F db/15°F wb Outdoor Air	2.25 COP	
	≥135,000 Btu/h (Cooling Capacity)	47°F db/43°F wb Outdoor Air	3.2 COP	AHRI 340/360
		17°F db/15°F wb Outdoor Air	2.05 COP	
Through-the-Wall (Air Cooled, Heating Mode)	<30,000 Btu/h[d]	Split System	7.4 HSPF	AHRI 210/240
		Single Package	7.4 HSPF	
Small-Duct High-Velocity (Air Cooled, Heating Mode)	< 65,000 Btu/h[d]	Split System	6.8 HSPF	AHRI 210/240
Water-Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	68°F Entering Water	4.2 COP	AHRI/ISO-13256-1
Groundwater-Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	50°F Entering Water	3.6 COP	AHRI/ISO-13256-1
Ground Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	32°F Entering Water	3.1 COP	AHRI/ISO-13256-1

[a] Reserved.
[b] IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.
[c] Deduct 0.2 from the required EERs and IEERs for units with a heating section other than electric resistance heat.
[d] Applies to all units, including single-phase and three-phase. For single-phase air-cooled heat pumps < 65,000 Btu/h, SEER and HSPF values are those set by NAECA.
[e] Reserved.

TABLE 14-1C
WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Units	Path A[b]		Path B[b]		Test Procedure[a]
			Full Load	IPLV	Full Load	IPLV	
Air Cooled Chillers[e]	<150 Tons	EER	>9.562	>12.500	NA[c]	NA[c]	AHRI 550/590
	≥150 Tons	EER	>9.562	>12.750	NA[c]	NA[c]	
Air Cooled, Without Condenser, Electrically Operated[e]	All Capacities	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements					
Water Cooled, Electrically Operated, Reciprocating	All Capacities	Reciprocating units must comply with water cooled positive displacement efficiency requirements					
Water Cooled, Electrically Operated, Positive Displacement	<75 Tons	kW/ton	<0.780	<0.630	<0.800	<0.600	
	≥75 Tons and <150 Tons		<0.775	<0.615	<0.790	<0.586	
	≥150 Tons and <300 Tons		<0.680	<0.580	<0.718	<0.540	
	≥ 300 Tons		<0.620	<0.540	<0.639	<0.490	
Water Cooled, Electrically Operated, Centrifugal	<150 Tons	kW/ton	<0.634	<0.596	<0.639	<0.450	
	≥150 Tons and <300 Tons		<0.634	<0.596	<0.639	<0.450	
	≥ 300 Tons and <600 Tons		<0.576	<0.549	<0.600	<0.400	
	≥600 Tons		<0.570	<0.539	<0.590	<0.400	
Air Cooled, Absorption Single Effect	All Capacities	COP	>0.600	NR[d]	NA[c]	NA[c]	AHRI 560-92
Water Cooled, Absorption Single Effect	All Capacities	COP	>0.700	NR[d]	NA[c]	NA[c]	
Absorption Double Effect, Indirect-Fired	All Capacities	COP	>1.000	>1.050	NA[c]	NA[c]	
Absorption Double Effect, Direct-Fired	All Capacities	COP	>1.000	>1.000	NA[c]	NA[c]	

For SI: 1 Btu/h = 0.2931 W

[a] The chiller equipment requirements do not apply for chillers used in low temperature applications where the design leaving fluid temperature is less than 38°F.

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

[c] NA means that this requirement is not applicable and cannot be used for compliance.

[d] NR means that there are no minimum requirements for this category.

[e] Chilled water plants and buildings with more than 500 tons total capacity shall not have more than 100 tons provided by air-cooled chillers.

TABLE 14-1D

PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, ROOM AIR CONDITIONERS, AND ROOM AIR CONDITIONER HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category (Input)	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
PTAC (Cooling Mode) Standard Size	All Capacities	95°F db Outdoor Air	12.5 - (0.213 x Cap/1000)[b] EER	AHRI 310/380
		82°F db Outdoor Air	14.7 - (0.213 x Cap/1000)[b] EER	
PTAC (Cooling Mode) Nonstandard Size[c]	All Capacities	95°F db Outdoor Air	10.9 - (0.213 x Cap/1000)[b] EER	
		82°F db Outdoor Air	13.1 - (0.213 x Cap/1000)[b] EER	
PTHP (Cooling Mode) Standard Size	All Capacities	95°F db Outdoor Air	12.3 - (0.213 x Cap/1000)[b] EER	
		82°F db Outdoor Air	14.5 - (0.213 x Cap/1000)[b] EER	
PTHP (Cooling Mode) Nonstandard Size[c]	All Capacities	95°F db Outdoor Air	10.8 - (0.213 x Cap/1000)[b] EER	
		82°F db Outdoor Air	13.0 - (0.213 x Cap/1000)[b] EER	
PTHP (Heating Mode) New Construction	All Capacities		3.2 - (0.026 x Cap/1000)[b] COP	
PTHP (Heating Mode) Replacements[c]	All Capacities		2.9 - (0.026 x Cap/1000)[b] COP	
SPVAC (Cooling Mode)	<65,000 Btu/h	95°F db/75°F wb Outdoor Air	9.0 EER	AHRI 390
	≥65,000 Btu/h and <135,000 Btu/h		8.9 EER	
	≥135,000 Btu/h and <240,000 Btu/h		8.6 EER	
SPVHP (Cooling Mode)	<65,000 Btu/h	95°F db/75°F wb Outdoor Air	9.0 EER	
	≥65,000 Btu/h and <135,000 Btu/h		8.9 EER	
	≥135,000 Btu/h and <240,000 Btu/h		8.6 EER	
SPVAC (Heating Mode)	<65,000 Btu/h	47°F db/43° wb Outdoor Air	3.0 COP	
	≥65,000 Btu/h and <135,000 Btu/h		3.0 COP	
	≥135,000 Btu/h and <240,000 Btu/h		29.COP	
Room Air Conditioners, with Louvered Sides	< 6,000 Btu/h		9.7 EER	ANSI/AHAM RAC-1
	≥6,000 Btu/h and < 8,000 Btu/h		9.7 EER	
	≥ 8,000 Btu/h and < 14,000 Btu/h		9.8 EER	
	≥14,000 Btu/h and < 20,000 Btu/h		9.7 EER	
	≥20,000 Btu/h		8.5 EER	
Room Air Conditioners, without Louvered Sides	< 8,000 Btu/h		9.0 EER	
	≥8,000 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] Reserved.

[b] 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.

[c] Nonstandard size units must be factory labeled as follows: "MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Nonstandard size efficiencies apply only to units being installed in existing sleeves having an external wall opening of less than 16-in. high or less than 42-in. wide, and having a cross-sectional area less than 670 square inches.

[d] Casement room air conditioners are not separate product classes under current minimum efficiency column.

[e] New room air conditioner standards, covered by NAECA became effective October 1, 2000.

TABLE 14-1E
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category (Input)	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Warm Air Furnace, Gas-Fired	< 225,000 Btu/h (66 kW)		78% AFUE or 80% E_t[c]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥225,000 Btu/h (66 kW)	Maximum Capacity[c] Minimum Capacity[c]	80% E_c[f]	ANSI Z21.47
Warm Air Furnace, Oil-Fired	< 225,000 Btu/h (66 kW)		78% AFUE or 80% E_t[c]	DOE 10 CFR Part 430 or UL 727
	≥225,000 Btu/h (66 kW)	Maximum Capacity[b] Minimum Capacity[b]	81% E_t[g] ——	UL 727
Warm Air Duct Furnaces, Gas-Fired	All Capacities	Maximum Capacity[b] Minimum Capacity[b]	80% E_c[e] ——	ANSI Z83.9
Warm Air Unit Heaters, Gas-Fired	All Capacities	Maximum Capacity[b] Minimum Capacity[b]	80% E_c[h] ——	ANSI Z83.8
Warm Air Unit Heaters, Oil-Fired	All Capacities	Maximum Capacity[b] Minimum Capacity[b]	80% E_c[e] ——	UL 731

[a] Reserved.
[b] Minimum and maximum ratings as provided for and allowed by the unit's controls.
[c] Combination units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) may comply with either rating.
[d] E_t = Thermal efficiency. See test procedure for detailed discussion.
[e] E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
[f] E_c = Combustion efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[g] E_t = Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[h] E_c = Combustion efficiency. Units must also include an IID, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those unit heaters where combustion air is drawn from the conditioned space.

TABLE 14-1F
BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type[f]	Sub Category	Size Category[b]	Minimum Efficiency[b]	Test Procedure
Boilers, Hot Water	Gas-Fired	< 300,000 Btu/h	80% AFUE	DOE 10 CFR Part 430
		≥300,000 Btu/h and ≤ 2,500,000 Btu/h	80% E_t	DOE 10 CFR Part 431
		> 2,500,000 Btu/h[a]	82% E_c	
	Oil-Fired[c]	< 300,000 Btu/h	80% AFUE	DOE 10 CFR Part 430
		≥300,000 Btu/h and ≤ 2,500,000 Btu/h	82% E_t	DOE 10 CFR Part 431
		> 2,500,000 Btu/h[a]	84% E_c	
Boilers, Steam	Gas-Fired	< 300,000 Btu/h	75% AFUE	DOE 10 CFR Part 430
	Gas-Fired – All except natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	79% E_t	DOE 10 CFR Part 431
		> 2,500,000 Btu/h	79% E_t	
	Gas-Fired, Natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	77% E_t	DOE 10 CFR Part 431
		> 2,500,000 Btu/h	77% E_t	
	Oil-Fired[c]	< 300,000 Btu/h	80% AFUE	DOE 10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h	81% E_t	DOE 10 CFR Part 431
		> 2,500,000 Btu/h[a]	81% 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] Maximum capacity - Minimum and maximum ratings as provided for and allowed by the unit's controls.
[c] Includes oil-fired (residual).
E_c = Combustion efficiency (100% less flue losses). See reference document for detailed information.
E_t = Thermal efficiency. See reference document for detailed information.

TABLE 14-1G
PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Sub-Category or Rating Condition	Minimum Efficiency[a,b,c]	Test Procedure
Propeller or Axial Fan, Open Circuit Cooling Towers	All	95°F (35°C) Entering Water 85°F (29°C) Leaving Water 75°F (24°C) wb Outdoor Air	≥38.2 gpm/hp (3.23 L/s-kW)	CTI ATC-105 and CTI STD-201
Centrifugal Fan, Open Circuit Cooling Towers	All	95°F (35°C) Entering Water 85°F (29°C) Leaving Water 75°F (24°C) wb Outdoor Air	≥ 20.0 gpm/hp (1.7 L/s-kW)	CTI ATC-105 and CTI STD-201
Propeller or Axial Fan, Closed Circuit Cooling Towers	All	102°F (39°C) Entering Water 90°F (32°C) Leaving Water 75°F (24°C) wb Outdoor Air	≥ 14.0 gpm/hp	CTI ATC-105S and CTI STD-201
Centrifugal Fan, Closed Circuit Cooling Towers	All	102°F (39°C) Entering Water 90°F (32°C) Leaving Water 75°F (24°C) wb Outdoor Air	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201
Air Cooled Condensers	All	125°F (52°C) Condensing Temperature R22 Test Fluid 190°F (88°C) Entering Gas Temperature 15°F (8°C) Subcooling 95°F (35°C) Entering Drybulb	≥176,000 Btu/h·hp 69 COP	AHRI 460

[a] For purposes of this table, open circuit cooling tower performance is defined as the process water flow rating of tower at thermal rating conditions listed in this table divided by the fan nameplate rated motor power.
[b] For purposes of this table, closed circuit cooling tower performance is defined as the process water flow rating of tower at thermal conditions listed in this table divided by the sum of fan motor nameplate power.
[c] For the 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.

TABLE 14-2 RESERVED
TABLE 14-3 RESERVED

TABLE 14-4A
ENERGY EFFICIENT ELECTRIC MOTORS
MINIMUM NOMINAL FULL-LOAD EFFICIENCY

	Minimum Nominal Full-Load Efficiencies (%) Before 12/19/2010					
	Open Motors			Enclosed Motors		
Number of Poles	2	4	6	2	4	6
Synchronous Speed (RPM)	3,600	1,800	1,200	3,600	1,800	1,200
Motor HP						
1.0	---	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2.0	84.0	84.0	85.5	84.0	84.0	86.5
3.0	84.0	86.5	86.5	85.5	87.5	87.5
5.0	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10.0	88.5	89.5	90.2	89.5	89.5	89.5
15.0	89.2	91.0	90.2	90.2	91.0	90.2
20.0	90.2	91.0	91.0	90.2	91.0	90.2
25.0	91.0	91.7	91.7	91.0	92.4	91.7
30.0	91.0	92.4	92.4	91.0	92.4	91.7
40.0	91.7	93.0	93.0	91.7	93.0	93.0
50.0	92.4	93.0	93.0	92.4	93.0	93.0
60.0	93.0	93.6	93.6	93.0	93.6	93.6
75.0	93.0	94.1	93.6	93.0	94.1	93.6
100.0	93.0	94.1	94.1	93.6	94.5	94.1
125.0	93.6	94.5	94.1	94.5	94.5	94.1
150.0	93.6	95.0	94.5	94.5	95.0	95.0
200.0	94.5	95.0	94.5	95.0	95.0	95.0

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

TABLE 14-4B
ENERGY EFFICIENT ELECTRIC MOTORS
MINIMUM NOMINAL FULL-LOAD EFFICIENCY

	Minimum Nominal Full-Load Efficiencies (%) As of 12/19/2010					
	Open Motors			Enclosed Motors		
Number of Poles	2	4	6	2	4	6
Synchronous Speed (RPM)	3,600	1,800	1,200	3,600	1,800	1,200
Motor HP						
1.0	77.0	85.5	82.5	77.0	85.5	82.5
1.5	84.0	86.5	86.5	84.0	86.5	87.5
2.0	85.5	86.5	87.5	85.5	86.5	88.5
3.0	85.5	89.5	88.5	86.5	89.5	89.5
5.0	86.5	89.5	89.5	88.5	89.5	89.5
7.5	88.5	91.0	90.2	89.5	91.7	91.0
10.0	89.5	91.7	91.7	90.2	91.7	91.0
15.0	90.2	93.0	91.7	91.0	92.4	91.7
20.0	91.0	93.0	92.4	91.0	93.0	91.7
25.0	91.7	93.6	93.0	91.7	93.6	93.0
30.0	91.7	94.1	93.6	91.7	93.6	93.0
40.0	92.4	94.1	94.1	92.4	94.1	94.1
50.0	93.0	94.5	94.1	93.0	94.5	94.1
60.0	93.6	95.0	94.5	93.6	95.0	94.5
75.0	93.6	95.0	94.5	93.6	95.4	95.4
100.0	93.6	95.4	95.0	94.1	95.4	95.0
125.0	94.1	95.4	95.0	95.0	95.4	95.0
150.0	94.1	95.8	95.4	95.0	95.8	95.8
200.0	95.0	95.8	95.4	95.4	96.2	95.8
250.0	95.0	95.8	95.4	95.8	96.2	95.8
300.0	95.4	95.8	95.4	95.8	96.2	95.8
350.0	95.4	95.8	95.4	95.8	96.2	95.8
400.0	95.8	95.8	95.8	95.8	96.2	95.8
450.0	95.8	96.2	96.2	95.8	96.2	95.8
500.0	95.8	96.2	96.2	95.8	96.2	95.8

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

TABLE 14-5
DUCT INSULATION

Duct Type	Duct Location	Insulation R-Value	Other Requirements
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-7	Approved weather proof barrier
Outside air intake	Within conditioned space	R-7	See Section 1414.2
Supply, Return, Outside air intake	Not within conditioned space: in concrete, in ground	R-5.3	
Supply with supply air temperature <55°F or >105°F	Within conditioned space	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/ft^3 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/ft^3 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/ ft^{3}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/ ft^3 mineral or glass fiber blanket, 2.0 inch 1.5 to 3.0 lb/ ft^3 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 14-6
MINIMUM PIPE INSULATION (INCHES)[1]

Fluid Design Operating Temp. Range, °F	Insulation Conductivity		Nominal Pipe or Tube Size (in.)				
	Conductivity Range Btu • in./(h • ft^2 • °F)	Mean Rating Temp. °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	> 8
Heating Systems (Steam, Steam Condensate and Hot water)[2]							
≥350	0.32-0.34	250	3.0	3.5	3.5	4.5	4.5
251-350	0.29-0.32	200	2.0	3.0	3.5	3.5	3.5
201-250	0.27-0.30	150	2.0	2.0	2.5	2.5	2.5
141-200	0.25-0.29	125	1.5	1.5	1.5	2.0	2.0
105-140	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
Domestic and Service Hot Water Systems							
≥105	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine and Refrigerant)							
40-60	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
≤40	0.22-0.28	100	1.0	1.5	1.5	1.5	2.0

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

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

   Where

   T = Minimum insulation thickness (in.)
   r = Actual outside radius of pipe (in.)
   t = Insulation thickness from Table 5-12 for applicable fluid temperature and pipe size
   K = Conductivity of alternate material at the mean rating temperature indicated for the applicable fluid temperature, Btu ∘ in/(h • ft^2 • °F)
   k = The upper value of the conductivity range listed in Table 5-12 for the applicable fluid temperature

2. Piping insulation is not required between the control valve and coil on Runouts when the control valve is located within 4 feet of the coil and the pipe size is 1 inch or less.

CHAPTER 15
LIGHTING, MOTORS, AND TRANSFORMERS

1501 Scope: Interior and exterior lighting, electric motors, and transformers shall comply with the requirements of this chapter.

SECTION 1510 -- GENERAL REQUIREMENTS:

Lighting and motors shall comply with Sections 1511 through 1514. Lighting systems shall comply with one of the following paths:

a. Prescriptive Lighting Option:
Interior Section 1521, or
Exterior Section 1522.

b. Lighting Power Allowance Option:
Interior Section 1531, or
Exterior Section 1532.

c. Systems Analysis. See Section 1141.4.

The compliance path selected for interior and exterior lighting need not be the same. However, interior and exterior lighting cannot be traded.

Transformers shall comply with Section 1540.

FIGURE 15A
LIGHTING, MOTOR, AND TRANSFORMER COMPLIANCE OPTIONS

Section Number	Subject	Prescriptive Lighting Option	Lighting Power Allowance Option	Systems Analysis Option
1510	General Requirements	X	X	X
1511	Electric Motors	X	X	X
1512	Exempt Lighting	X	X	X
1513	Lighting Controls	X	X	X
1514	Exit Signs	X	X	X
1520	Prescriptive Lighting Option	X		
1521	Prescriptive Interior Lighting Requirements	X		
1522	Prescriptive Exterior Lighting Requirements	Sec. 1532		
1530	Lighting Power Allowance Option		X	
1531	Interior Lighting Power Allowance		X	
1532	Exterior Lighting Power Allowance		X	
1540	Transformers	X	X	X
RS-29	Systems Analysis			X

1511 Electric Motors: All permanently wired polyphase motors of 1 hp or more, which are not part of an HVAC system, shall comply with Section 1437.

EXCEPTIONS: 1. Motors that are an integral part of specialized process equipment.

2. Where the motor is integral to a listed piece of equipment for which no complying motor has been approved.

1512 Exempt Lighting: The use of these exemptions is at the applicant's option.

1512.1 Exempt Spaces: The following rooms, spaces, and areas are exempt from the requirements in Sections 1520 through 1522 and 1530 through 1532 but shall comply with all other requirements of this chapter.

⇨ 1. High risk security areas or any area identified by building officials as requiring additional lighting.

2. Spaces designed for primary use by the visually impaired or hard of hearing.

⇨ 3. Electrical/mechanical equipment rooms.

⇨ 4. The sanctuary portion of a house of worship, defined as the space or room where the worship service takes place. Classrooms, meeting rooms, offices and multipurpose rooms that are part of the same facility are not exempt.

1512.2 Exempt Lighting Equipment: The following lighting equipment and tasks are exempt from the lighting requirements of Section 1520 through 1522 and need not be included when calculating the installed lighting power under Sections 1530 through 1532 but shall comply with all other requirements of this chapter. All other lighting in areas that are not exempted by Section 1512.2, where exempt tasks and equipment are used, shall comply with all of the requirements of this chapter.

1. Special lighting needs for research.

2. Emergency lighting that is automatically OFF during normal building operation.

3. Lighting that is part of machines, equipment or furniture.

4. Lighting that is used solely for indoor plant growth during the hours of 10:00 p.m. to 6:00 a.m. However, such lighting shall not be exempt unless it is in addition to general area lighting, is located in a separate fixture, and is controlled by an independent control device.

5. Lighting for theatrical productions, television broadcasting (including sports facilities), and special effects

lighting for stage areas and dance floors in entertainment facilities. However, such lighting shall not be exempt unless it is in addition to general area lighting, is located in a separate fixture, and is controlled by an independent control device.

6. Lighting in galleries, museums and in main building entry lobbies for exhibits, inspection and restoration. However, such lighting shall not be exempt unless it is in addition to general area lighting, is located in a separate fixture, and is controlled by an independent control device.

7. Lighting specifically designed for use during medical or dental procedures and lighting integral to medical equipment. However, such lighting shall not be exempt unless it is in addition to general area lighting, is located in a separate fixture, and is controlled by an independent control device. Use of a portion of the lamps in a multilamp fixture, provided those lamps have an independent control device, shall be permitted.

8. Lighting integral to food warming equipment or specifically for food preparation. However, such lighting shall not be exempt unless it is in addition to general area lighting, is located in a separate fixture, and is controlled by an independent control device.

9. Audio-visual and video-conferencing lighting with multilevel or dimming controls in rooms with permanently installed audio-visual equipment or video-conferencing equipment.

10. Permanently installed undershelf or undercabinet lighting that has an automatic shutoff control device integral to or is directly attached to the luminaires or is automatically controlled by a wall-mounted control device that turns off the lighting whenever that particular space is unoccupied. Other permanently installed undershelf or undercabinet lighting that is not automatically controlled is not exempt and other partition-mounted lighting that is providing general illumination is not exempt and shall be included when determining compliance with the lighting requirements of Sections 1520 through 1522 and Sections 1530 through 1532.

11. Lighting used for aircraft painting.

1513 Lighting Controls: Lighting, including exempt lighting in Section 1512, shall comply with this section. Where occupancy sensors are cited, they shall have the features listed in Section 1513.6.1. Where automatic time switches are cited, they shall have the features listed in Section 1513.6.2.

1513.1 Local Control and Accessibility: 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. Automatic controls.
3. Controls requiring trained operators.
4. Controls for safety hazards and security.

1513.2 Area Controls: 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 ft^2.

1513.3 Daylight Zone Control: All daylighted zones, as defined in Chapter 2, 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.

In all areas with skylights, monitors or other fenestration at or above ceiling level and in all areas with windows, all permanent luminaires in the daylighted zone shall be controlled by automatic daylight sensing controls. The primary daylighted zone shall be controlled separately from the secondary daylighted zone.

Automatic daylight sensing controls shall:

1. Be capable of reducing the light output of the controlled luminaires while maintaining a uniform level of illuminance by either:
   a. Continuous dimming to at least 20% light output; or
   b. Step switching of each lamp in individual luminaires (noncontinuous dimming devices shall have adjustable separation (deadband) of on and off points to prevent short cycling) and provide an automatic OFF control, switching alternate luminaires is not permitted except with single lamp luminaires; or
   c. Step dimming by reducing the output of all of the lamps in individual luminaires by at least 50% and provide an automatic OFF control.
2. Control only luminaires within the daylighted area.
3. Incorporate time-delay circuits to prevent cycling of light level changes of less than three minutes.

Any switching devices installed to override the automatic daylighting control shall comply with the criteria in Section 1513.6.2 items a through e.

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, west). Daylight zones under overhead glazing shall be controlled separately from daylight zones adjacent to vertical glazing. ⇦

EXCEPTION: The following are exempt from the requirement for automatic daylighting controls in Section 1513.3:

1. Retail spaces adjacent to vertical glazing (retail spaces under overhead glazing are not exempt).

2. Lighting exempted by Section 1512.

3. Display, exhibition and specialty lighting complying with Section 1513.4.

4. The following spaces are exempt from the requirements for automatic daylighting controls in Section 1513.3 provided they have occupancy sensor controls that comply with Section 1513.6.1:

a. Small spaces in the daylighted zone that are normally unoccupied (such as a storage room with a window or restrooms;

b. Rooms less than 300 square feet; and

c. Conference rooms 300 square feet and larger that have a lighting control system with at least four scene options and an occupancy sensor control that complies with Section 1513.6.1.

5. HID lamps with automatic controls that are capable of reducing the power consumption by at least 50%.

6. HID lamps 100 watts or less.

1513.4 Display, Exhibition and Specialty Lighting Controls: All display, exhibition or specialty lighting shall be controlled independently of general area lighting.

1513.5 Automatic Shut-off Controls, Exterior: Lighting for all exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours. Lighting not designated for dusk-to-dawn operation shall be controlled by either:

a. A combination of a photosensor and a time switch; or

b. An astronomical time switch.

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

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

1513.6 Automatic Shut-Off Controls, Interior: All buildings shall be equipped with separate automatic controls to shut off the lighting in all spaces during unoccupied hours. Within these buildings, all office areas less than 300 ft^2 enclosed by walls or ceiling-height partitions, and all meeting and conference rooms, and all school classrooms, and warehouse and storage spaces shall be equipped with occupancy sensors that comply with Section 1513.6.1. For other spaces, automatic controls may be an occupancy sensor, time switch or other device capable of automatically shutting off lighting. For hotel and motel guestrooms, see Section 1513.7.

EXCEPTIONS: 1. Areas that must be continuously illuminated (e.g., 24-hour convenience stores), or illuminated in a manner requiring manual operation of the lighting.

2. Emergency lighting and means of egress illumination as required by code that are automatically OFF during normal building operation.

3. Switching for industrial or manufacturing process facilities as may be required for production.

4. 24-hour occupancy areas in hospitals and laboratory spaces.

5. Areas in which medical or dental tasks are performed are exempt from the occupancy sensor requirement.

6. Dwelling units.

1513.6.1 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. Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off lights when the space is occupied.

EXCEPTION: Occupancy sensors in stairwells are allowed to have two step lighting (high-light and low-light) provided the control fails in the high-light position.

1513.6.2 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 and incorporate an automatic holiday "shut-off" feature, which turns off all loads for at least 24 hours and then resumes normally scheduled operations. 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 which:

a. is readily accessible;

b. is located so that a person using the device can see the lights or the areas controlled by the switch, or so that the area being illuminated is annunciated;

c. is manually operated;

d. allows the lighting to remain on for no more than 2 hours when an over-ride is initiated; and

e. controls an area not exceeding 5,000 ft^2 or 5% of the building footprint for footprints over 100,000 ft^2, whichever is greater.

1513.7 Lighting Controls: Hotel and motel guest rooms and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles. In addition, a minimum of one of the following control technologies shall be required in hotel/motel guest rooms with over 50 guest rooms such that all the power to the lights and switched outlets in a hotel or motel guest room would be turned off when the occupant is not in the room:

1. Controls that are activated by the room occupant via the primary room access method - key, card, deadbolt, etc.

2. Occupancy sensor controls that are activated by the occupant's presence in the room.

1513.8 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. See Section 1416 for complete requirements. Optional examples of test methods and forms can be found in Reference Standard 34.

1514 Exit Signs: Exit signs shall have an input power demand of 5 Watts or less per sign.

SECTION 1520 — PRESCRIPTIVE LIGHTING OPTION

1521 Prescriptive Interior Lighting Requirements: Spaces for which the Unit Lighting Power Allowance in Table 15-1 is 0.80 W/ft^2 or greater may use unlimited numbers of lighting fixtures and lighting energy, provided that the installed lighting fixtures comply with all four of the following criteria:

a. one- or two-lamp (bur not three- or more lamp);

b. luminaires have a reflector or louver assembly to direct the light (bare lamp strip or industrial fixtures do not comply with this section);

c. fitted with type T-1, T-2, T-4, T-5, T-8 or compact fluorescent lamps from 5 to 60 watts (but not T-10 or T-12 lamps); and

d. hard-wired fluorescent electronic dimming ballasts with photocell or programmable dimming control for all lamps in all zones (nondimming electronic ballasts and electronic ballasts that screw into medium base sockets do not comply with this section).

Track lighting is not allowed under this path.

EXCEPTIONS: 1. Up to a total of 5% of installed lighting fixtures may use any type of ballasted lamp and do not require dimming controls.

2. Clear safety lenses are allowed in food prep and serving areas and patient care areas in otherwise compliant fixtures.

3. LED lights.

4. Metal halide lighting which complies with all three of the following criteria:

i. luminaires or lamps which have a reflector or louver assembly to direct the light;

ii. fixtures are fitted with ceramic metal halide lamps not exceeding 150 watts; and

iii. electronic ballasts.

1522 Prescriptive Exterior Lighting Requirements: See Section 1532.

SECTION 1530 — LIGHTING POWER ALLOWANCE OPTION

The installed lighting wattage shall not exceed the lighting power allowance. Lighting wattage includes lamp and ballast wattage.

Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following criteria:

a. The wattage of line voltage incandescent or tungsten-halogen luminaires not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaire.

b. The wattage of luminaires with permanently installed or remote ballasts or transformers shall be the operating input wattage of the maximum lamp/auxiliary combination based on values from the auxiliary manufacturer's literature or recognized testing laboratories or shall be the maximum labeled wattage of the luminaire.

c. For line voltage track and plug-in busway, designed to allow the addition and/or relocation of luminaires without altering the wiring of the system, the wattage shall be:

1. The specified wattage of the luminaires included in the system with a minimum of 50 watts per lineal foot of track or actual luminaire wattage, whichever is greater; or
2. The wattage limit of permanent current limiting device(s) on the system.

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

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

No credit towards compliance with the lighting power allowances shall be given for the use of any controls, automatic or otherwise.

1531 Interior Lighting Power Allowance: The interior lighting power allowance shall be calculated by multiplying the gross interior floor area, in square feet, by the appropriate unit lighting power allowance, in watts per square foot, for the use as specified in Table 15-1. Accessory uses, including corridors, lobbies and toilet facilities shall be included with the primary use.

The lighting power allowance for each use shall be separately calculated and summed to obtain the interior lighting power allowance.

In cases where a lighting plan for only a portion of a building is submitted, the interior lighting power allowance shall be based on the gross interior floor area covered by the plan. Plans submitted for common areas only, including corridors, lobbies and toilet facilities shall use the lighting power allowance for common areas in Table 15-1.

When insufficient information is known about the specific use of the space, the allowance shall be based on the apparent intended use of the space.

1532 Exterior Lighting Power Allowance: All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or qualifies for one of the following exceptions.

The total exterior lighting power allowance for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are designated on the building plans to be illuminated and are permitted in Table 15-2B for the applicable lighting zone. Trade-offs are allowed only among exterior lighting applications listed in the Table 15-2B "Tradable Surfaces" section. The lighting zone for building exterior is determined from Table 15-2A unless otherwise specified by the local jurisdiction.

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

a. Specialized signal, directional, and marker lighting associated with transportation.
b. Lighting integral to signs.
c. Lighting integral to equipment or instrumentation and installed by its manufacturer.
d. Lighting for theatrical purposes, including performance, stage, film production, and video production.
e. Lighting for athletic playing areas.
f. Temporary lighting.
g. Lighting for industrial production.
h. Theme elements in theme/amusement parks.
i. Lighting used to highlight features of public monuments.
j. Group U Occupancy accessory to Group R-3 or R-4 Occupancy.

SECTION 1540 — TRANSFORMERS

The minimum efficiency of a low voltage dry-type distribution transformer shall be the Class I Efficiency Levels for distribution transformers specified in Table 4-2 of the "Guide for Determining Energy Efficiency for Distribution Transformers" published by the National Electrical Manufacturers Association (NEMA TP-1-2002).

TABLE 15-1
UNIT LIGHTING POWER ALLOWANCE (LPA)

Use[1]	LPA[2] (W/ft²)
Automotive facility	0.85
Convention center	1.10
Courthouse	1.10
Cafeterias, fast food establishments[5], restaurants/bars[5]	1.20
Dormitory	0.85
Dwelling units	1.00
Exercise center	0.95
Gymnasia[9], assembly spaces[9]	0.95
Health care clinic	1.00
Hospital, nursing homes, and other Group I-1 and I-2 Occupancies	1.20
Hotel/motel	1.00
Laboratory spaces (all spaces not classified "laboratory" shall meet office and other appropriate categories)	1.62
Laundries	1.20
Libraries[5]	1.20
Manufacturing facility	1.20
Museum	1.00
Office buildings, office/administrative areas in facilities of other use types (including but not limited to schools, hospitals, institutions, museums, banks, churches)[5,7,11]	0.91
Parking garages	0.20
Penitentiary and other Group I-3 Occupancies	0.90
Police and fire stations	0.90
Post office	1.00
Retail[10], retail banking, mall concourses, wholesale stores (pallet rack shelving)	1.33
School buildings (Group E Occupancy only), school classrooms, day care centers	1.00
Theater, motion picture	0.97
Theater, performing arts	1.25
Transportation	0.80
Warehouses	0.50
Workshop	1.20
Plans Submitted for Common Areas Only[7]	
Main floor building lobbies[3] (except mall concourses)	1.10
All building common areas, corridors, toilet facilities and washrooms, elevator lobbies, including Group R-1 and R-2 Occupancies	0.80

Footnotes For Table 15-1

1. In cases in which a general use and a specific use are listed, the specific use shall apply. In cases in which a use is not mentioned specifically, the *Unit Lighting Power Allowance* shall be determined by the building official. This determination shall be based upon the most comparable use specified in the table. See Section 1512 for exempt areas.

2. The watts per square foot may be increased, by 2% per foot of ceiling height above 20 feet, unless specifically directed otherwise by subsequent footnotes.

3. The watts per square foot of room may be increased by 2% per foot of ceiling height above 12 feet.

4. For all other spaces, such as seating and common areas, use the *Unit Lighting Power Allowance* for assembly.

5. The watts per square foot of room may be increased by 2% per foot of ceiling height above 9 feet.

6. Reserved.

7. For conference rooms and offices less than 150 ft^2 with full-height partitions, a Unit Lighting Power Allowance of 1.1 w/ft^2 may be used.

8. Reserved.

9. For indoor sport tournament courts with adjacent spectator seating over 5,000, the *Unit Lighting Power Allowance* for the court area is 2.60 W/ft^2.

10. Display window illumination installed within 2 feet of the window, provided that the display window is separated from the retail space by walls or at least three-quarter-height partitions (transparent or opaque) and lighting for free-standing display where the lighting moves with the display are exempt.

An additional lighting power allowance is allowed for merchandise display luminaires installed in retail sales areas that are specifically designed and directed to highlight merchandise. The following additional wattages apply:

i. 0.6 watts per square foot of sales floor area not listed in items ii and iii below;

ii. 1.4 watts per square foot of furniture, clothing, cosmetics or artwork floor area; or

iii. 2.5 watts per square foot of jewelry, crystal or china floor area.

The specified floor area for items i, ii, or iii above, and the adjoining circulation paths shall be identified and specified on building plans. Calculate the additional power allowance by multiplying the above LPDs by the sales floor area for each department excluding major circulation paths. The total additional lighting power allowance is the sum of allowances for sales categories i, ii, or iii plus an additional 1,000 watts for each separate tenant larger than 250 square feet in area.

The additional wattage is allowed only if the merchandise display luminaires comply with all of the following:

(a) Located on ceiling-mounted track or directly on or recessed into the ceiling itself (not on the wall).

⇨ (b) Adjustable in both the horizontal and vertical axes (vertical axis only is acceptable for fluorescent and other fixtures with two points of track attachment).

This additional lighting power is allowed only if the lighting is actually installed and automatically controlled, separately from the general lighting, to be turned off during nonbusiness hours. This additional power shall be used only for the specified luminaires and shall not be used for any other purpose.

11. Provided that a floor plan, indicating rack location and height, is submitted, the square footage for a warehouse may be defined, for computing the interior *Unit Lighting Power Allowance,* as the floor area not covered by racks plus the vertical face area (access side only) of the racks. The height allowance defined in footnote 2 applies only to the floor area not covered by racks.

TABLE 15-2A
EXTERIOR LIGHTING ZONES

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

TABLE 15-2B
LIGHTING POWER DENSITIES FOR BUILDING EXTERIORS

Specific area description		Zone 1	Zone 2	Zone 3	Zone 4
Base site allowance[1]		500 W	600 W	750 W	1300 W
Tradable Surfaces[2]					
Uncovered Parking Areas	Parking lots and drives	0.04 W/ft^2	0.06 W/ft^2	0.10 W/ft^2	0.13 W/ft^2
Building Grounds	Walkways less than 10 ft wide	0.7 W/linear foot	0.7 W/ linear foot	0.8 W/ linear foot	1.0 W/ linear foot
	Walkways 10 ft wide or greater Plaza areas Special feature areas	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.2 W/ft^2
	Exterior Stairways	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
	Pedestrian tunnel	0.15 W/ft^2	0.15 W/ft^2	0.2 W/ft^2	0.3 W/ft^2
	Landscaping	0.04 W/ft^2	0.05 W/ft^2	0.05 W/ft^2	0.05 W/ft^2
Building Entrances and Exits	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2
Sales Canopies	Free standing and attached	0.6 W/ft^2	0.6 W/ft^2	0.8 W/ft^2	1.0 W/ft^2
Outdoor Sales	Open areas[3]	0.25 W/ft^2	0.25 W/ft^2	0.5 W/ft^2	0.7 W/ft^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	No Allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Non-Tradable Surfaces[4]					
Building Facades		No Allowance	0.1 W/ft^2 for each illuminated wall or surface[5]	0.15 W/ft^2 for each illuminated wall or surface[6]	0.2 W/ft^2 for each illuminated wall or surface[7]
Automated teller machines and night depositories		270 W per location[8]	270 W per location[8]	270 W per location[8]	270 W per location[8]
Entrances and gatehouse inspection stations at guarded facilities		0.75 W/ft^2 of covered & uncovered area	0.75 W/ft^2 of covered & uncovered area	0.75 W/ft^2 of covered & uncovered area	0.75 W/ft^2 of covered & uncovered area
Loading areas for law enforcement, fire, ambulance and other emergency service vehicles		0.5 W/ft^2 of covered & uncovered area	0.5 W/ft^2 of covered & uncovered area	0.5 W/ft^2 of covered & uncovered area	0.5 W/ft^2 of covered & uncovered area
Material handling and associated storage					0.5 W/ft^2
Drive-up Windows & Doors		400W per drive-through	400W per drive-through	400W per drive-through	400W per drive-through
Parking near 24-hour retail entrances		800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry

FOOTNOTES FOR TABLE 15-2B:

1. Base site allowance may be used in tradable or nontradable surfaces.
2. Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.
3. Including vehicle sales lots.
4. Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.
5. May alternately use 2.5 watts per linear foot for each wall or surface length.
6. May alternately use 3.75 watts per linear foot for each wall or surface length.
7. May alternately use 5 watts per linear foot for each wall or surface length.
8. An additional 90 watts is allowed per additional ATM location.

APPENDIX

REFERENCE STANDARD 29
(RS-29)

NONRESIDENTIAL BUILDING DESIGN BY SYSTEMS ANALYSIS

REFERENCE STANDARD
NONRESIDENTIAL BUILDING DESIGN BY SYSTEMS ANALYSIS

NOTE: Washington State Energy Code Reference Standard 29 (RS-29) is a modified version of Appendix G from ASHRAE/IESNA Standard 90.1-2007. RS-29 has been completely rewritten from the 2006 Edition.

SECTION 1 — GENERAL

The following definitions apply to use of RS-29:

Baseline building design: A computer representation of a hypothetical design based on the proposed building project. This representation is used as the basis for calculating the baseline building performance for rating above-standard design.

Baseline building performance: The annual energy consumption for a building design intended for use as a baseline for rating above-standard design.

Proposed building performance: The annual energy consumption calculated for a proposed design.

Proposed design: A computer representation of the actual proposed building design or portion thereof used as the basis for calculating the proposed building performance.

1.1 General: This Standard establishes design criteria in terms of total energy consumption of a building, including all of its systems.

The building permit application for projects utilizing this Standard shall include in one submittal all building and mechanical drawings and all information necessary to verify that the building envelope and mechanical design for the project corresponds with the annual energy analysis. If credit is proposed to be taken for lighting energy savings, then an electrical permit application shall also be submitted and approved prior to the issuance of the building permit. If credit is proposed to be taken for energy savings from other components, then the corresponding permit application (e.g., plumbing, boiler, etc.) shall also be submitted and approved prior to the building permit application. Otherwise, components of the project that would not be approved as part of a building permit application shall be modeled the same in both the proposed building and the baseline building and shall comply with the requirements of the Washington State Energy Code.

1.2 Performance Rating: This performance rating method requires conformance with the following provisions:

All requirements of Sections 1310 through 1314, 1410 through 1416, 1440 through 1443, 1450 through 1454, 1510 through 1514, and 1540 are met. These sections contain the mandatory provisions of the standard and are prerequisites for this rating method. The improved performance of the proposed building design is calculated in accordance with provisions of this appendix using the following formula:

Percentage Improvement = 100 x (Baseline building performance - Proposed building performance) / Baseline building performance

A "proposed building" designed in accordance with this standard will be deemed as complying with this Code, if the calculated annual energy consumption is 5% LESS than that of a corresponding "baseline building."

NOTES: 1. Both the proposed building performance and the baseline building performance shall include all end-use load components, such as receptacle and process loads.

2. Neither the proposed building performance nor the baseline building performance are predictions of actual energy consumption or costs for the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this procedure, changes in energy rates between design of the building and occupancy, and the precision of the calculation tool.

1.3 Trade-Off Limits: When the proposed modifications apply to less than the whole building, only parameters related to the systems to be modified shall be allowed to vary. Parameters relating to unmodified existing conditions or to future building components shall be identical for determining both the baseline building performance and the proposed building performance. Future building components shall meet the requirements of Sections 1320 through 1334, 1420 through 1439, and 1530 through 1532.

1.4 Documentation Requirements: Simulated performance shall be documented, and documentation shall be submitted to the building official. The information submitted shall include the following:

a. Calculated values for the baseline building performance, the proposed building performance, and the percentage improvement.

b. A list of the energy-related features that are included in the design and on which the performance rating is based. This list shall document all energy features that differ between the models used in the baseline building performance and proposed building performance calculations.

c. Input and output report(s) from the simulation program or compliance software including a breakdown of energy usage by at least the following components: Lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the amount of time any loads are not met by the HVAC system for both the proposed design and baseline building design.

d. An explanation of any error messages noted in the simulation program output.

SECTION 2 — SIMULATION GENERAL REQUIREMENTS

2.1 Performance Calculations: The proposed building performance and baseline building performance shall be calculated using the following:

a. The same simulation program.

b. The same weather data.

2.2 Simulation Program: The simulation program shall be a computer-based program for the analysis of energy consumption in buildings (a program such as, but not limited to, DOE-2, BLAST, or EnergyPlus). The simulation program shall include calculation methodologies for the building components being modeled. For components that cannot be modeled by the simulation program, the exceptional calculation methods requirements in Section 2.5 may be used.

2.2.1 The simulation program shall be approved by the building official and shall, at a minimum, have the ability to explicitly model all of the following:

a. 8760 hours per year.

b. Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays.

c. Thermal mass effects.

d. Ten or more thermal zones.

e. Part-load performance curves for mechanical equipment.

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

g. Air-side economizers with integrated control.

h. Baseline building design characteristics specified in Section 3.

2.2.2 The simulation program shall have the ability to either: (1) Directly determine the proposed building performance and baseline building performance; or (2) produce hourly reports of energy use by an energy source suitable for determining the proposed building performance and baseline building performance using a separate calculation engine.

2.2.3 The simulation program shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with generally accepted engineering standards and handbooks (for example, ASHRAE Handbook-Fundamentals) for both the proposed design and baseline building design.

2.2.4 The simulation program shall be tested according to ASHRAE Standard 140.

2.3 Climatic Data: The simulation program shall perform the simulation using hourly values of climatic data, such as temperature and humidity from representative climatic data, for the site in which the proposed design is to be located. For cities or urban regions with several climatic data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site. The selected weather data shall be approved by the building official.

2.4 Energy Conversion: The comparison between the baseline building and proposed design shall be expressed as kBtu input per square foot of conditioned floor area per year at the building site. 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.

EXCEPTION: On-site renewable energy sources or site-recovered energy shall not be considered to be consumed energy and shall not be included in the proposed building performance. Where on-site renewable or site-recovered sources are used, the baseline building performance shall be based on the energy source used as the backup energy source or on the use of electricity if no backup energy source has been specified.

2.5 Exceptional Calculation Methods: Where no simulation program is available that adequately models a design, material, or device, the building official may approve an exceptional calculation method to demonstrate above-standard performance using this method.

Applications for approval of an exceptional method shall include documentation of the calculations performed and theoretical and/or empirical information supporting the accuracy of the method.

SECTION 3 — Calculation of the Proposed and Baseline Building Performance

3.1 Building Performance Calculations: The simulation model for calculating the proposed and baseline building performance shall be developed in accordance with the requirements in Table 3.1.

For the baseline building and the proposed building, 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.

3.1.1 Baseline HVAC System Type and Description: HVAC systems in the baseline building design shall be based on usage, number of floors, conditioned floor area, and heating source as specified in Table 3.1.1A and shall conform with the system descriptions in Table 3.1.1B. For systems 1, 2, 3, and 4, each thermal block shall be modeled with its own HVAC system. For systems 5, 6, 7, and 8, each floor shall be modeled with a separate HVAC system. Floors with identical thermal blocks can be grouped for modeling purposes.

EXCEPTIONS: 1. Use additional system type(s) for nonpredominant conditions (i.e., residential/nonresidential or heating source) if those conditions apply to more than 20,000 ft^2 of conditioned floor area.

2. If the baseline HVAC system type is 5, 6, 7, or 8, use separate single-zone systems conforming with the requirements of system 3 or system 4 (depending on building heating source) for any spaces that have occupancy or process loads or schedules that differ significantly from the rest of the building. Peak thermal loads that differ by 10 $Btu/h \cdot ft^2$ or more from the average of other spaces served by the system or schedules that differ by more than 40 equivalent full-load hours per week from other spaces served by the system are considered to differ significantly. Examples where this exception may be applicable include, but are not limited to, computer server rooms, natatoriums, and continually occupied security areas.

3. If the baseline HVAC system type is 5, 6, 7, or 8, use separate single-zone systems conforming with the requirements of system 3 or system 4 (depending on building heat source) for any zones having special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates.

4. For laboratory spaces with a minimum of 5000 cfm of exhaust, use system type 5 or 7 that reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.

3.1.1.1 Purchased Heat: For systems using purchased hot water or steam on-site boilers shall not be modeled in the baseline building design.

3.1.2 General Baseline HVAC System Requirements: HVAC systems in the baseline building design shall conform with the general provisions in this section.

3.1.2.1 Equipment Efficiencies: All HVAC equipment in the baseline building design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with Section 1411. Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.

3.1.2.2 Equipment Capacities: The equipment capacities for the baseline building design shall be based on sizing runs for each orientation (per Table 3.1, No. 5a) and shall be oversized by 15% for cooling and 25% for heating, i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be 1.15 for cooling and 1.25 for heating. Unmet load hours for the proposed design or baseline building designs shall not exceed 300 (of the 8760 hours simulated), and unmet load hours for the proposed design shall not exceed the number of unmet load hours for the baseline building design by more than 50. If unmet load hours in the proposed design exceed the unmet load hours in the baseline building by more than 50, simulated capacities in the baseline building shall be decreased incrementally and the building resimulated until the unmet load hours are within 50 of the unmet load hours of the proposed design. If unmet load hours for the proposed design or baseline building design exceed 300, simulated capacities shall be increased incrementally, and the building with unmet loads resimulated until unmet load hours are reduced to 300 or less. Alternatively, unmet load hours exceeding these limits may be accepted at the discretion of the building official provided that sufficient justification is given indicating that the accuracy of the simulation is not significantly compromised by these unmet loads.

3.1.2.2.1 Sizing Runs: Weather conditions used in sizing runs to determine baseline equipment capacities may be based either on hourly historical weather files containing typical peak conditions or on design days developed using 99.6% heating design temperatures and 1% dry-bulb and 1% wet-bulb cooling design temperatures.

3.1.2.3 Preheat Coils: If the HVAC system in the proposed design has a preheat coil and a preheat coil can be modeled in the baseline system, the baseline system shall be modeled with a preheat coil controlled in the same manner as the proposed design.

3.1.2.4 Fan System Operation: Supply and return fans shall operate continuously whenever spaces are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours. If the supply fan is modeled as cycling and fan energy is included in the energy-efficiency rating of the equipment, fan energy shall not be modeled explicitly. Supply, return, and/or exhaust fans will remain on during occupied and unoccupied hours in spaces that have health and safety mandated minimum ventilation requirements during unoccupied hours.

3.1.2.5 Ventilation: Minimum outdoor air ventilation rates shall be the same for the proposed and baseline building designs.

EXCEPTION: When modeling demand-control ventilation in the proposed design when its use is not required by Section 1412.8.

3.1.2.6 Economizers: Outdoor air economizers shall not be included in baseline HVAC Systems 1 and 2 where not required by Section 1433. Outdoor air economizers shall be included in baseline HVAC Systems 3 through 8.

EXCEPTION: Economizers shall not be included for systems meeting one or more of the exceptions listed below.

1. Systems that include gas-phase air cleaning to meet the requirements of Section 6.1.2 in Standard 62.1. This exception shall be used only if the system in the proposed design does not match the building design.

2. Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems. This exception shall only be used if the system in the proposed design does not use an economizer. If the exception is used, an economizer shall not be included in the baseline building design.

3.1.2.7 Economizer High-Limit Shutoff: The high-limit shutoff shall be a dry-bulb switch with 75°F setpoint temperatures.

3.1.2.8 Design Airflow Rates: System design supply airflow rates for the baseline building design shall be based on a supply-air-to-room-air temperature difference of 20°F or the required ventilation air or makeup air, whichever is greater. If return or relief fans are specified in the proposed design, the baseline building design shall also be modeled with fans serving the same functions and sized for the baseline system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.

3.1.2.9 System Fan Power: System fan electrical power for supply, return, exhaust, and relief (excluding power to fan-powered VAV boxes) shall be calculated using the following formulas:

For Systems 1 and 2,

$$P_{fan} = CFM_S \times 0.3$$

For Systems 3 through 8,

$$P_{fan} = bhp \times 746/\text{Fan Motor Efficiency}$$

Where:

P_{fan}	=	Electric power to fan motor (watts)
bhp	=	Brake horsepower of baseline fan motor from Table 3.1.2.9
Fan Motor Efficiency	=	The efficiency from Table 14-4 for the next motor size greater than the bhp using the enclosed motor at 1800 rpm
CFM_S	=	The baseline system maximum design supply fan airflow rate in cfm

3.1.2.10 Exhaust Air Energy Recovery: Systems shall conform with the provisions of Chapter 14.

3.1.3 System-Specific Baseline HVAC System Requirements: Baseline HVAC systems shall conform with provisions in this section, where applicable, to the specified baseline system types as indicated in section headings.

3.1.3.1 Heat Pumps (Systems 2 and 4): Electric air-source heat pumps shall be modeled with electric auxiliary heat. The systems shall be controlled with multistage space thermostats and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when outdoor air temperature is less than 40°F.

3.1.3.2 Type and Number of Boilers (Systems 1, 5, and 7): The boiler plant shall use the same fuel as the proposed design and shall be natural draft, except as noted in Section 3.1.1.1. The baseline building design boiler plant shall be modeled as having a single boiler if the baseline building design plant serves a conditioned floor area of 15,000 ft^2 or less and as having two equally sized boilers for plants serving more than 15,000 ft^2. Boilers shall be staged as required by the load.

3.1.3.3 Hot-Water Supply Temperature (Systems 1, 5, and 7): Hot-water design supply temperature shall be modeled as 180°F and design return temperature as 130°F.

3.1.3.4 Hot-Water Supply Temperature Reset (Systems 1, 5, and 7): Hot-water supply temperature shall be reset based on outdoor dry-bulb temperature using the following schedule: 180°F at 20°F and below, 150°F at 50°F and above, and ramped linearly between 180°F and 150°F at temperatures between 20°F and 50°F.

3.1.3.5 Hot-Water Pumps (Systems 1, 5, and 7): The baseline building design hot-water pump power shall be 19 W/gpm. The pumping system shall be modeled as primary-only with continuous variable flow. Hot-water systems serving 120,000 ft^2 or more shall be modeled with variable-speed drives, and systems serving less than 120,000 ft^2 shall be modeled as riding the pump curve.

3.1.3.6 Piping Losses (Systems 1, 5, 7, and 8): Piping losses shall not be modeled in either the proposed or baseline building designs for hot water, chilled water, or steam piping.

3.1.3.7 Type and Number of Chillers (Systems 7 and 8): Electric chillers shall be used in the baseline building design regardless of the cooling energy source, e.g., direct-fired absorption, absorption from purchased steam, or purchased chilled water. The baseline building design's chiller plant shall be modeled with chillers having the number and type as indicated in Table 3.1.3.7 as a function of building peak cooling load.

3.1.3.8 Chilled-Water Design Supply Temperature (Systems 7 and 8): Chilled-water design supply temperature shall be modeled at 44°F and return water temperature at 56°F.

3.1.3.9 Chilled-Water Supply Temperature Reset (Systems 7 and 8): Chilled-water supply temperature shall be reset based on outdoor dry-bulb temperature using the following schedule: 44°F at 80°F and above, 54°F at 60°F and below, and ramped linearly between 44°F and 54°F at temperatures between 80°F and 60°F.

3.1.3.10 Chilled-Water Pumps (Systems 7 and 8): The baseline building design pump power shall be 22 W/gpm. Chilled-water systems with a cooling capacity of 300 tons or more shall be modeled as primary/secondary systems with variable-speed drives on the secondary pumping loop. Chilled-water pumps in systems serving less than 300 tons cooling capacity shall be modeled as primary/secondary systems with secondary pump riding the pump curve.

3.1.3.11 Heat Rejection (Systems 7 and 8): The heat rejection device shall be an axial fan cooling tower with two-speed fans. Condenser water design supply temperature shall be 85°F or 10°F approaching design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F. The tower shall be controlled to maintain a 70°F leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. The baseline building design condenser-water pump power shall be 19 W/gpm. Each chiller shall be modeled with separate condenser water and chilled-water pumps interlocked to operate with the associated chiller.

3.1.3.12 Supply Air Temperature Reset (Systems 5 through 8): The air temperature for cooling shall be reset higher by 5°F under the minimum cooling load conditions.

3.1.3.13 VAV Minimum Flow Setpoints (Systems 5 and 7): Minimum volume setpoints for VAV reheat boxes shall be 0.4 cfm/ft^2 of floor area served or the minimum ventilation rate, whichever is larger.

3.1.3.14 Fan Power (Systems 6 and 8): Fans in parallel VAV fan-powered boxes shall be sized for 50% of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume setpoints for fan-powered boxes shall be equal to 30% of peak design flow rate or the rate required to meet the minimum outdoor air ventilation requirement, whichever is larger. The supply air temperature setpoint shall be constant at the design condition.

3.1.3.15 VAV Fan Part-Load Performance (Systems 5 through 8): VAV system supply fans shall have variable-speed drives, and their part-load performance characteristics shall be modeled using either Method 1 or Method 2 specified in Table 3.1.3.15.

TABLE 3.1
MODELING REQUIREMENTS FOR CALCULATING PROPOSED AND BASELINE BUILDING PERFORMANCE

No. Proposed Building Performance	Baseline Building Performance
1. Design Model	
a. The simulation model of the proposed design shall be consistent with the design documents, including proper accounting of fenestration and opaque envelope types and areas; interior lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls. All end-use load components within and associated with the building shall be modeled, including, but not limited to, exhaust fans, parking garage ventilation fans, snow-melt and freeze-protection equipment, facade lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration, and cooking. Where the simulation program does not specifically model the functionality of the installed system, spreadsheets or other documentation of the assumptions shall be used to generate the power demand and operating schedule of the systems. b. All conditioned spaces in the proposed design shall be simulated as being both heated and cooled even if no heating or cooling system is to be installed, and temperature and humidity control setpoints and schedules shall be the same for proposed and baseline building designs. c. When the performance rating method is applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the proposed design exactly as they are defined in the baseline building design. Where the space classification for a space is not known, the space shall be categorized as an office space.	The baseline building design shall be modeled with the same number of floors and identical conditioned floor area as the proposed design.
2. Additions and Alterations	
It is acceptable to predict performance using building models that exclude parts of the existing building provided that all of the following conditions are met: a. Work to be performed in excluded parts of the building shall meet the requirements of Chapters 11 through 15. b. Excluded parts of the building are served by HVAC systems that are entirely separate from those serving parts of the building that are included in the building model. c. Design space temperature and HVAC system operating setpoints and schedules on either side of the boundary between included and excluded parts of the building are essentially the same. d. If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the building are on the same utility meter, the rate shall reflect the utility block or rate for the building plus the addition.	Same as Proposed Design
3. Space Use Classification	
Usage shall be specified using the building type or space type lighting classifications in accordance with Sections 1530 through 1531. The user shall specify the space use classifications using either the building type or space type categories but shall not combine the two types of categories. More than one building type category may be used in a building if it is a mixed-use facility. If space type categories are used, the user may simplify the placement of the various space types within the building model, provided that building-total areas for each space type are accurate.	Same as Proposed Design

No. Proposed Building Performance	Baseline Building Performance
4. Schedules	
Schedules capable of modeling hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, and HVAC system operation shall be used. The schedules shall be typical of the proposed building type as determined by the designer and approved by the building official. Default schedules are included in Tables 3.3A through 3.3J. HVAC Fan Schedules. Schedules for HVAC fans that provide outdoor air for ventilation shall run continuously whenever spaces are occupied and shall be cycled on and off to meet heating and cooling loads during unoccupied hours. **Exceptions:** a. Where no heating and/or cooling system is to be installed and a heating or cooling system is being simulated only to meet the requirements described in this table, heating and/or cooling system fans shall not be simulated as running continuously during occupied hours but shall be cycled on and off to meet heating and cooling loads during all hours. b. HVAC fans shall remain on during occupied and unoccupied hours in spaces that have health and safety mandated minimum ventilation requirements during unoccupied hours.	Same as Proposed Design Exception: Schedules may be allowed to differ between proposed design and baseline building design when necessary to model nonstandard efficiency measures, provided that the revised schedules have the approval of the building official. Measures that may warrant use of different schedules include, but are not limited to, lighting controls, natural ventilation, demand control ventilation, and measures that reduce service water heating loads.
5. Building Envelope	
All components of the building envelope in the proposed design shall be modeled as shown on architectural drawings or as built for existing building envelopes. **Exceptions:** The following building elements are permitted to differ from architectural drawings. a. All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate floor slabs, concrete floor beams over parking garages, roof parapet) shall be separately modeled using either of the following techniques: 1. Separate model of each of these assemblies within the energy simulation model. 2. Separate calculation of the U-factor for each of these assemblies. The U-factors of these assemblies are then averaged with larger adjacent surfaces using an area-weighted average method. This average U-factor is modeled within the energy simulation model. Any other envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described provided that it is similar to an assembly being modeled. If not separately described, the area of an envelope assembly shall be added to the area of an assembly of that same type with the same orientation and thermal properties. b. Exterior surfaces whose azimuth orientation and tilt differ by less than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers. c. For exterior roofs, the roof surface may be modeled with a reflectance of 0.45 if the reflectance of the proposed design roof is greater than 0.70 and its emittance is greater than 0.75 or has a minimum SRI of 82. Reflectance values shall be based on testing in accordance with ASTM C1549, ASTM E903, or ASTM E1918, and emittance values shall be based on testing in accordance with ASTM C1371 or ASTM E408, and SRI shall be based on ASTM E1980 calculated at medium wind speed. All other roof surfaces shall be modeled with a reflectance of 0.30. d. Manual fenestration shading devices such as blinds or shades shall not be modeled. Automatically controlled fenestration shades or blinds may be modeled. Permanent shading devices such as fins, overhangs, and light shelves may be modeled.	Equivalent dimensions shall be assumed for each exterior envelope component type as in the proposed design; i.e., the total gross area of exterior walls shall be the same in the proposed and baseline building designs. The same shall be true for the areas of roofs, floors, and doors, and the exposed perimeters of concrete slabs on grade shall also be the same in the proposed and baseline building designs. The following additional requirements shall apply to the modeling of the baseline building design: a. **Orientation.** The baseline building performance shall be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, and 270 degrees, then averaging the results. The building shall be modeled so that it does not shade itself b. **Opaque Assemblies.** Opaque assemblies used for new buildings or additions shall conform with the following common, lightweight assembly types and shall match the appropriate assembly maximum U-factors in Tables 13-1 and 13-2: Roofs--Insulation entirely above deck Above-grade walls--Steel-framed Floors--Steel-joist Opaque door types shall match the proposed design and conform to the U-factor requirements from the same tables. Slab-on-grade floors shall match the F-factor for unheated slabs from the same tables. Opaque assemblies used for alterations shall conform with Section 1132.1. c. **Vertical Fenestration.** Vertical fenestration areas for new buildings and additions shall equal that in the proposed design or 40% of gross above-grade wall area, whichever is smaller, and shall be distributed on each face of the building in the same proportions in the proposed design. Fenestration U-factors and SHGC shall match the appropriate requirements in Tables 13-1 and 13-2. All vertical glazing shall be assumed to be flush with the exterior wall, and no shading projections shall be modeled. Manual window shading devices such as blinds or shades shall not be modeled. The fenestration areas for envelope alterations shall reflect the limitations on area, U-factor, and SHGC as described in Section 1132.1.

No. Proposed Building Performance	Baseline Building Performance
5. Building Envelope (Continued)	
	d. **Skylights and Glazed Smoke Vents.** Skylight area shall be equal to that in the proposed building design or 5% of the gross roof area that is part of the building envelope, whichever is smaller. If the skylight area of the proposed building design is greater than 5% of the gross roof area, baseline skylight area shall be decreased by an identical percentage in all roof components in which skylights are located to reach the 5% skylight-to-roof ratio. Skylight orientation and tilt shall be the same as in the proposed building design. Skylight U-factor and SHGC properties shall match the appropriate requirements in Tables 13-1 and 13-2. e. **Roof albedo.** All roof surfaces shall be modeled with a reflectivity of 0.30. f. **Existing Buildings.** For existing building envelopes, the baseline building design shall reflect existing conditions prior to any revisions that are part of the scope of work being evaluated.
6. Lighting	
Lighting power in the proposed design shall be determined as follows: a. Where a complete lighting system exists, the actual lighting power for each thermal block shall be used in the model. b. Where a lighting system has been designed, lighting power shall be determined in accordance with Chapter 15. c. Where lighting neither exists nor is specified, lighting power shall be determined in accordance with the building area method for the appropriate building type. d. Lighting system power shall include all lighting system components shown or provided for on the plans (including lamps and ballasts and task and furniture-mounted fixtures). **Exception:** For multifamily dwelling units, hotel/motel guest rooms, and other spaces in which lighting systems are connected via receptacles and are not shown or provided for on building plans, assume identical lighting power for the proposed and baseline building designs in the simulations. e. Lighting power for parking garages and building facades shall be modeled. f. Credit may be taken for the use of automatic controls for daylight utilization not otherwise required by Section 1513 but only if their operation is either modeled directly in the building simulation or modeled in the building simulation through schedule adjustments determined by a separate daylighting analysis approved by the building official. g. For automatic lighting controls in addition to those required for minimum code compliance under Section 1513, credit may be taken for automatically controlled systems by reducing the connected lighting power by the applicable percentages listed in Table 3.2. Alternatively, credit may be taken for these devices by modifying the lighting schedules used for the proposed design, provided that credible technical documentation for the modifications are provided to the building official.	Lighting power in the baseline building design shall be determined using the same categorization procedure and categories as the proposed design with lighting power set equal to the maximum allowed for the corresponding method and category in Chapter 15. Automatic lighting controls (e.g., programmable controls or automatic controls for daylight utilization) shall be modeled in the baseline building design as required by Section 1513.
7. Thermal Blocks – HVAC Zones Designated	
Where HVAC zones are defined on HVAC design drawings, each HVAC zone shall be modeled as a separate thermal block. **Exception:** Different HVAC zones may be combined to create a single thermal block or identical thermal blocks to which multipliers are applied, provided that all of the following conditions are met: a. The space use classification is the same throughout the thermal block. b. All HVAC zones in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations vary by less than 45 degrees. c. All of the zones are served by the same HVAC system or by the same kind of HVAC system.	Same as Proposed Design

No. Proposed Building Performance	Baseline Building Performance
8. Thermal Blocks – HVAC Zones Not Designated	
Where the HVAC zones and systems have not yet been designed, thermal blocks shall be defined based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules, and in combination with the following guidelines: a. Separate thermal blocks shall be assumed for interior and perimeter spaces. Interior spaces shall be those located greater than 15 ft from an exterior wall. Perimeter spaces shall be those located within 15 ft of an exterior wall. b. Separate thermal blocks shall be assumed for spaces adjacent to glazed exterior walls; a separate zone shall be provided for each orientation, except that orientations that differ by less than 45 degrees may be considered to be the same orientation. Each zone shall include all floor area that is 15 ft or less from a glazed perimeter wall, except that floor area within 15 ft of glazed perimeter walls having more than one orientation shall be divided proportionately between zones. c. Separate thermal blocks shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features. d. Separate thermal blocks shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.	Same as Proposed Design
9. Thermal Blocks – Multifamily Residential Buildings	
Residential spaces shall be modeled using at least one thermal block per dwelling unit, except that those units facing the same orientation may be combined into one thermal block. Corner units and units with roof or floor loads shall only be combined with units sharing these features.	Same as Proposed Design
10. HVAC Systems	
The HVAC system type and all related performance parameters in the proposed design, such as equipment capacities and efficiencies, shall be determined as follows: a. Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. b. Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the standard rating conditions specified in Section 1411 if required by the simulation model. c. Where no heating system exists or no heating system has been specified, the heating system classification shall be assumed to be electric, and the system characteristics shall be identical to the system modeled in the baseline building design. d. Where no cooling system exists or no cooling system has been specified, the cooling system shall be identical to the system modeled in the baseline building design.	The HVAC system(s) in the baseline building design shall be of the type and description specified in Section 3.1.1, shall meet the general HVAC system requirements specified in Section 3.1.2, and shall meet any system-specific requirements in Section 3.1.3 that are applicable to the baseline HVAC system type(s).
11. Service Hot Water Systems	
The service hot-water system type and all related performance parameters, such as equipment capacities and efficiencies, in the proposed design shall be determined as follows: a. Where a complete service hot-water system exists, the proposed design shall reflect the actual system type using actual component capacities and efficiencies.	The service hot-water system in the baseline building design shall use the same energy source as the corresponding system in the proposed design and shall conform with the following conditions: a. Where the complete service hot-water system exists, the baseline building design shall reflect the actual system type using the actual component capacities and efficiencies.

No. Proposed Building Performance	Baseline Building Performance
11. Service Hot Water Systems (Continued)	
b. Where a service hot-water system has been specified, the service hot-water model shall be consistent with design documents.	b. Where a new service hot-water system has been specified, the system shall be sized using the same methods and values as the proposed design and the equipment shall match the minimum efficiency requirements in Chapter 14. Where the energy source is electricity, the heating method shall be electrical resistance.
c. Where no service hot-water system exists or has been specified but the building will have service hot-water loads, a service hot-water system shall be modeled that matches the system in the baseline building design and serves the same hot-water loads.	c. Where no service hot-water system exists or has been specified but the building will have service hot-water loads, a service water system(s) using electrical-resistance heat and matching minimum efficiency requirements of Chapter 14 shall be assumed and modeled identically in the proposed and baseline building designs.
d. For buildings that will have no service hot-water loads, no service hot-water system shall be modeled.	d. For buildings that will have no service hot-water loads, no service hot-water heating shall be modeled. e. Where a combined system has been specified to meet both space heating and service water heating loads, the baseline building system shall use separate systems meeting the minimum efficiency requirements applicable to each system individually. f. For large, 24-hour-per-day facilities that meet the prescriptive criteria for use of condenser heat recovery systems described in Section 1436.3, a system meeting the requirements of that section shall be included in the baseline building design regardless of the exceptions to Section 1436.3. **Exception:** If a condenser heat recovery system meeting the requirements described in Section 1436.3 cannot be modeled, the requirement for including such a system in the actual building shall be met as a prescriptive requirement in accordance with Section 1436.3, and no heat-recovery system shall be included in the proposed or baseline building designs. g. Service hot-water energy consumption shall be calculated explicitly based upon the volume of service hot water required and the entering makeup water and the leaving service hot-water temperatures. Entering water temperatures shall be estimated based upon the location. Leaving temperatures shall be based upon the end-use requirements. h. Where recirculation pumps are used to ensure prompt availability of service hot water at the end use, the energy consumption of such pumps shall be calculated explicitly. i. Service water loads and usage shall be the same for both the baseline building design and the proposed design and shall be documented by the calculation procedures recommended by the manufacturer's specifications or generally accepted engineering methods. Exceptions: 1. Appliances that are not built-in (e.g., washing machines) and plumbing fixtures (e.g., faucets and low-flow showerheads) shall be modeled the same for both the baseline building design and the proposed design. Other service hot-water usage can be demonstrated to be reduced by documented water conservation measures that reduce the physical volume of service water required. Such reduction shall be demonstrated by calculations. 2. Service hot-water energy consumption can be demonstrated to be reduced by reducing the required temperature of service mixed water, by increasing the temperature, or by increasing the temperature of the entering makeup water. Examples include alternative sanitizing technologies for dishwashing and heat recovery to entering makeup water. Such reduction shall be demonstrated by calculations. 3. Service hot-water usage can be demonstrated to be reduced by reducing the hot fraction of mixed water to achieve required operational temperature. Examples include shower or laundry heat recovery to incoming cold-water supply, reducing the hot-water fraction required to meet required mixed-water temperature. Such reduction shall be demonstrated by calculations.

No. Proposed Building Performance	Baseline Building Performance
12. Receptacle and Other Loads	
Receptacle and process loads where not otherwise covered by this code, such as those for office and other equipment, shall be estimated based on the building type or space type category and shall be assumed to be identical in the proposed and baseline building designs. These loads shall be included in simulations of the building and shall be included when calculating the baseline building performance and proposed building performance. Default process loads are included in Table 3.1.4.	Other systems, such as motors covered by Sections 1437, 1438 and 1511, and miscellaneous loads shall be modeled as identical to those in the proposed design including schedules of operation and control of the equipment. Where there are specific efficiency requirements in Sections 1437, 1438 and 1511, these systems or components shall be modeled as having the lowest efficiency allowed by those requirements. Where no efficiency requirements exist, power and energy rating or capacity of the equipment shall be identical between the baseline building and the proposed design with the following exception: Variations of the power requirements, schedules, or control sequences of the equipment modeled in the baseline building from those in the proposed design may be allowed by the building official based upon documentation that the equipment installed in the proposed design represents a significant verifiable departure from documented conventional practice. The burden of this documentation is to demonstrate that accepted conventional practice would result in baseline building equipment different from that installed in the proposed design. Occupancy and occupancy schedules may not be changed. Process loads must represent a minimum of 25% of the total baseline building energy consumption. For buildings where the process energy is less than 25% of the baseline building energy usage, the permit submittal must include supporting documentation substantiating that process energy inputs are appropriate.
13. Modeling Limitations to the Simulation Program	
If the simulation program cannot model a component system included in the proposed design explicitly, substitute a thermodynamically similar component model that can approximate the expected performance of the component that cannot be modeled explicitly.	Same as Proposed Design

TABLE 3.1.1A
BASELINE HVAC SYSTEM TYPE

Building Type	Fossil Fuel, Fossil/Electric Hybrid, and Purchased Heat	Electric and Other
Residential	System 1 – PTAC	System 2 – PTHP
Nonresidential and 3 Floors or Less and <25,000 ft^2	System 3 – PSZ – AC	System 4 – PSZ – HP
Nonresidential and 4 or 5 Floors and <25,000 ft^2 or 5 Floors or Less and 25,000 ft^2 to 150,000 ft^2	System 5 – Packaged VAV with Reheat	System 6 – Packaged VAV
Nonresidential and More than 5 Floors or >150,000 ft^2	System 7 – VAV with Reheat	System 8 – VAV with PFP Boxes

Notes:
Residential building types include dormitory, hotel, motel, and multifamily. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered nonresidential.

Where no heating system is to be provided or no heating energy source is specified, use the "Electric and Other" heating source classification.

Where attributes make a building eligible for more than one baseline system type, use the predominant condition to determine the system type for the entire building.

For laboratory spaces with a minimum of 5000 cfm of exhaust, use system type 5 or 7 and reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.

TABLE 3.1.1B
BASELINE SYSTEM DESCRIPTIONS

System No.	System Type	Fan Control	Cooling Type	Heating Type[1]
1. PTAC	Packaged terminal air conditioner	Constant volume	Direct expansion	Hot-water fossil fuel boiler
2. PTHP	Packaged terminal heat pump	Constant volume	Direct expansion	Electric heat pump
3. PSZ-AC	Packaged rooftop air conditioner	Constant volume	Direct expansion	Fossil fuel furnace
4. PSZ-HP	Packaged rooftop heat pump	Constant volume	Direct expansion	Electric heat pump
5. Packaged VAV with Reheat	Packaged rooftop VAV with reheat	VAV	Direct expansion	Hot-water fossil fuel boiler
6. Packaged VAV with PFP Boxes	Packaged rooftop VAV with reheat	VAV	Direct expansion	Electric resistance
7. VAV with Reheat	Packaged rooftop VAV with reheat	VAV	Chilled water	Hot-water fossil fuel boiler
8. VAV with PFP Boxes	VAV with reheat	VAV	Chilled water	Electric resistance

[1] Heating fuel source for the baseline system shall match the proposed system in all cases for both primary and supplemental heat

TABLE 3.1.2.9
BASELINE FAN BRAKE HORSEPOWER

Baseline Fan Motor Brake Horsepower	
Constant Volume Systems 3-4	**Variable Volume Systems 5-8**
CFM_S x 0.00094 + A	CFM_S x 0.0013 + A

Where A is calculated as follows using the pressure drop adjustment from the proposed building design and the design flow rate of the baseline building system.

A = Sum of [PD x CFM_D / 4131] where:

PD = Each applicable pressure drop adjustment from the table below in inches w.c.

CFM_D = The design air flow through each applicable device from the table below in cubic feet per minute

Do not include pressure drop adjustments for evaporative coolers or heat recovery devices that are not required in the baseline building system by Section 3.1.2.10

TABLE 3.1.2.9B
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

Device	Adjustment
Fully ducted return and/or exhaust air systems	0.5 in. w.c.
Return and/or exhaust airflow control devices	0.5 in. w.c.
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate filtration credit: MERV 9 through 12	0.5 in. w.c.
Particulate filtration credit: MERV 13 through 15	0.9 in. w.c.
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Heat recovery device	Pressure drop of device at fan system design condition
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design condition
Sound Attenuation Section	0.15 in. w.c.

TABLE 3.1.3.7
TYPE AND NUMBER OF CHILLERS

Building Peak Cooling Load	Number and Type of Chiller(s)
≤ 300 tons	1 water-cooled screw chiller
> 300 tons, <600 tons	2 water-cooled screw chillers sized equally
≥600	2 water-cooled centrifugal chillers minimum with chillers added so that no chiller is larger than 800 tons, all sized equally

TABLE 3.1.3.15
PART-LOAD PERFORMANCE FOR VAV FAN SYSTEMS

Method 1 – Part-Load Fan Power Data	
Fan Part-Load Ratio	**Fraction of Full-Load Power**
0.00	0.00
0.10	0.03
0.20	0.07
0.30	0.13
0.40	0.21
0.50	0.30
0.60	0.41
0.70	0.54
0.80	0.68
0.90	0.83
1.00	1.00

Method 2 – Part-Load Fan Power Equation		
P_{fan}	=	$0.0013 + 0.1470 \times PLR_{fan} + 0.95606 \times (PLR_{fan})^2 - 0.0998$
Where		
P_{fan}	=	Fraction of full-load fan power
PLR_{fan}	=	Fan part-load ration (current cfm/design cfm)

TABLE 3.1.4
ACCEPTABLE OCCUPANCY DENSITIES, RECEPTACLE POWER DENSITIES AND SERVICE HOT WATER CONSUMPTION[1]

Building Type	Occupancy Density[2] ft^2/Person (Btu/h· ft^2)	Receptacle Power Density[3], Watts/ ft^2 (Btu/h· ft^2)	Service Hot Water Quantities[4] Btu/h per 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 90.1-1989 and 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 3.2
POWER ADJUSTMENT PERCENTAGES
FOR AUTOMATIC LIGHTING CONTROLS

Automatic Control Device(s)	Exterior Lighting
1. Programmable timing control	0%
2. Occupancy sensor	10%
3. Occupancy sensor and programmable timing control	10%

TABLE 3.3A
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 90.1-1989 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 3.3B
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 90.1-1989 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 3.3C
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 90.1-1989 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 3.3D
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 90.1-1989 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 3.3E
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 90.1-1989 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 3.3F
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 90.1-1989 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 3.3G
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 90.1-1989 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 3.3H
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 90.1-1989 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 3.3I
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 90.1-1989 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 3.3J
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 90.1-1989 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.**

SECTION 4 — SUGGESTED SOFTWARE FOR SYSTEMS ANALYSIS APPROACH

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