WASHINGTON STATE ENERGY CODE

1997 EDITION

CHAPTER 51-11 WAC

WASHINGTON STATE BUILDING CODE COUNCIL

EFFECTIVE JULY 1, 1998

Copies of the State Building Codes may be obtained from:

Community, Trade and Economic Development
Washington State Building Code Council
Post Office Box 48300
Olympia, Washington 98504-8300
(360) 753-1184

Complete copies of the 1997 Uniform Building Code as published by the International Conference of Building Officials may be obtained from:

International Conference of Building Officials
Northwest Regional Office
2212 112th Avenue NE, Suite B-300
Bellevue, Washington 98004
(425) 451-9541

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1997 Washington State Energy Code
Chapter 51-11 WAC
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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 1997 Washington State Energy Code (WSEC) amends the 1994 WSEC Second Edition, 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:

Uniform Building Code, Standards and amendments -WAC 51-40;
Uniform Mechanical Code, Standards and amendments - WAC 51-42;
Uniform Fire Code, Standards and amendments - WAC 51-44, 51-45;
Uniform Plumbing Code, Standards and amendments - WAC 51-46, 51-47.

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 Uniform 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 2000 as part of its consideration of adoption of the 2000 series of uniform codes. Preliminary action will be taken each year on proposals submitted by the deadline.

It is the intent of the Council not to change the codes in effect until the 2000 codes would go into effect in 2001. 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: Chapter 11, Appendix Chapter 11, Sections 1003.3.1.1, 1003.3.1.2, 1003.3.1.5, and 1003.3.3.6 of Chapter 10 of the adopted Uniform Building Code; residential provisions of the State Energy Code (WAC 51-11), the Ventilation and Indoor Air Quality Code (WAC 51-13); and standards specifically adopted in Chapters 19.27 and 19.27A can not 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.

Effective Date: These rules were adopted by the State Building Code Council on November 14, 1997. The rules are effective throughout the state on July 1, 1998. (This version of the code is based on WAC 51-11 as published in WSR 98-03-003. It is subject to review by the State Legislature during the 1998 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. 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. This section also includes permits issued to install a mobile/manufactured home, commercial coach or factory built structure as those for which the fee shall be imposed. Exempt from the fee are plumbing, electrical, mechanical permits or permits issued pursuant to the Uniform 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 1998. Such fees may be changed by the State Legislature.

Opinions: Only at the request of local enforcement officials, 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 uniform codes amended by the Council. Final interpretation authority for any specific permit resides with the local enforcement official.

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FIRST EDITION
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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 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; Chapter 4.
2. A component performance approach for various building elements and mechanical systems and components; Chapter 5.
3. A prescriptive requirements approach; Chapter 6.

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 HVAC, service water heating 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.

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 building mechanical systems, and service water heating.

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 seven hundred fifty 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 heat loss which is less than or equal to the unimproved existing building, 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 Other than Group R Occupancy which is converted to Group R Occupancy 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 following requirements 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 to 6-6 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 in Group R Occupancy, glazing shall comply with the appropriate reference case in Tables 6-1 through 6-6.

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 while, for roof/ceilings, maintaining 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 Building Mechanical Systems: Those parts of systems which are altered or replaced shall comply with Section 503 of this Code.

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

101.3.2.8: Reserved

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 Group R Occupancies in each town, city and county, no later than July 1, 1991.

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 be 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 108.5 of the Washington State Uniform 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.

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) and Uniform Building Code and Standards Adoption and Amendment rules (Chapter 51-40 WAC). 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 over the following. Provided, in the case of conflict between the duct insulation requirements of this Code and the duct insulation requirements of Table 6D of the Uniform Mechanical Code (Chapter 51-42 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

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.

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.

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

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: Walls or the portion of walls which are entirely below the finished grade or which extend two feet or less above the finished grade.

BUILDING, EXISTING: See the Washington State Building Code.

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 ENVELOPE: The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from spaces exempted by the provisions of Section 101.3.1.

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.

COMFORT ENVELOPE: The area on a psychrometric chart enclosing all those conditions described in Standard RS-4, Figure No. 1, as being comfortable.

CONDITIONED SPACE: All spaces which are provided with heated and/or cooled air or which are capable of being maintained at temperatures over 50°F during the heating season, including adjacent connected spaces separated by an uninsulated component (e.g., basements, utility rooms, garages, corridors).

COOLED SPACE: Space within a building which is provided with a positive cooling supply.

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 undeSee **Net Heat Output, Net Heat Removal, Total On-Site Energy Input.**)

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

DEGREE DAY, HEATING: A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load of a building in winter. For any one day when the mean temperature is less than 65°F there exist as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65°F.

DOOR: An operable opening area in the shell of a conditioned space, excluding sliding glass doors, which is designed and used as a means of ingress and egress. A door may also include a double door one of which is fixed and one of which is operable.

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.

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**.)

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

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.

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

F-VALUE: (See F-factor.)

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 glass doors and glass block walls. The daylight opening area in all other doors shall be considered glazing for the purpose of calculating glazing area. The daylight opening area in all other doors is included in the door U-factor and shall not be considered in calculations of glazing U-factors.

GLAZING AREA: Total area of the glazing measured using the rough opening, and including the glazing, sash and frame. For sliding glass doors the glazing area is the rough opening area. For all other doors the glazing area is the daylight opening 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; includes opaque wall, window and door areas. The gross area of walls consists of all opaque wall areas, including foundation walls, between floor spandrels, peripheral edges of floors, window areas including sash, and door areas, where such surfaces are exposed to exterior ambient conditions and enclose a conditioned space including interstitial areas between two such spaces.

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: The sum of the areas of the roof/ceiling assembly, consisting of the total interior surface area of all elements, including skylights, which enclose a conditioned space.

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: Space within a building which is provided with a positive heating supply. Finished living space within a basement or registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space. (See **Positive Heating Supply**.)

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 the December 27, 1979, Federal Register, Vol. 44, No. 24, 10 CFR 430. 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.)

ILLUMINATION: The density of the luminous flux incident on a surface; it is the quotient of the luminous flux by the area of the surface when the latter is uniformly illuminated.

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.

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.**)

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 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.**)

NFRC: National Fenestration Rating Council.

NOMINAL R-VALUE: The thermal resistance of insulation as specified by the manufacturer according to recognized trade and engineering standards.

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.

OCCUPANCY: See the Washington State Uniform Building Code.

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

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

OUTDOOR AIR: Air taken from the outdoors and, therefore, not previously circulated through the system.

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-10.)

PACKAGED TERMINAL HEAT PUMP: A factory-selected combination of heating and cooling components, assemblies or sections intended for application in an individual room or zone. (For the complete technical definition, see Standard RS-21.)

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-96-72 or other approved dry cup method as specified in Standard RS-1.

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

POSITIVE COOLING SUPPLY: Mechanical cooling deliberately supplied to a space, such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space cooling components, such as evaporator coil cases and cooling distribution systems which are capable of maintaining air temperatures within the space of 85°F, or lower, at the exterior design conditions specified in Section 302.1. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this Code.

POSITIVE HEATING SUPPLY: Heat deliberately supplied to a space by design, such as a supply register, radiator or heating element. Also, heat indirectly supplied to a space through uninsulated surfaces of service water heaters and space heating components, such as furnaces, boilers and heating and cooling distribution systems which are capable of maintaining air temperature within the space of 50°F, or higher, at the exterior design conditions specified in Section 302.1. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this Code.

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).

PUBLIC FACILITY REST ROOM: A rest room used by the transient public on a regular (rather than casual) basis. Examples include rest rooms in service stations, airports, train terminals and convention halls. Rest rooms incorporated with private guest rooms in hotels, motels or dormitories and rest room facilities intended for the use of employees and not usually used by the general public are not considered public facility rest rooms.

RADIANT SLAB: A slab on grade containing heated pipes, ducts, or electric heating cables that constitute a radiant slab or portion thereof for a 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.

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.

ROOF/CEILING ASSEMBLY: 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 gross area of a roof/ceiling assembly consists of the total interior surface of such assembly, including skylights.

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.

SHALL: Denotes a mandatory code requirement.

SINGLE FAMILY: One and two family residential dwelling units with no more than two units in a single building.

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

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.

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.

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 whicb 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.

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.)

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•ft^2•°F).

THERMAL RESISTANCE (R): The reciprocal of thermal conductance (h•ft^2•°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•ft^2•°F). The U-factor applies to the fractional combinations of different materials used in series along the heat flow path.

THERMAL TRANSMITTANCE, OVERALL (U_0): The overall (average) heat transmission of a gross area of the exterior building envelope (Btu/h•ft^2•°F). The U_0-factor applies to the combined effect of the time rate of heat flows through the various parallel paths, such as windows, doors and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/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.

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

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

UNIFORM BUILDING CODE: The Washington State Uniform Building Code as modified by the Washington State Building Code Council.

UNIFORM MECHANICAL CODE: The Washington State Uniform Mechanical Code as modified by the Washington State Building Code Council.

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 sball 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 complies with this Code.

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.

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 with the horizontal plane, and separates conditioned from unconditioned space. Band joists between floors are to be considered a part of exterior walls.

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 0.6% column for winter and 0.5% column for summer from the Puget Sound Chapter of ASHRAE publication "Recommended Outdoor Design Temperatures, Washington State, ASHRAE." (See also Washington State Energy Code Manual.)

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

For all Occupancies, the minimum requirements for ventilation shall comply with the Washington State Ventilation and Indoor Air Quality Code (WAC 51-13).

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 Group R Occupancies shall comply with Section 402.1 through 402.6.

SECTION 402 – SYSTEMS ANALYSIS

402.1 Special Requirements for All Group R Occupancies

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 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. 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 energy use does not exceed the annual space heating and 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	
R-3 units	3000 Btu/h
R-1 units	1500 Btu/h
Domestic Hot Water Heater Setpoint	120°F
Domestic Hot Water Consumption	20 gallons per person perday.
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 Equipment Efficiency	
Electric resistance heat	1.00
Heat pumps	6.80 HSPF
Other fuels	0.78 AFUE

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.
4. Heating system efficiency.

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 not greater 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:** Group R Occupancy 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.

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 or 5-2, 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 21-29 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-25, 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 24 of Standard RS-1, listed in Chapter 7.
4. Results of parallel path correction factors for effective framing/cavity R-values as provided from the following table for metal stud walls and roof/ceilings:

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

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 2602 and/or 707 of the Uniform 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.

Alternatively, the thickness of roof/ceiling and wall 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, ceiling and/or wall space. In attics, the markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness and minimum settled 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. In cathedral ceilings and walls, the markers shall be affixed to the rafter and wall frame at alternating high and low intervals and marked with the minimum installed density and R-value with numbers a minimum 1.0 inch (25 mm) in height. Each marker shall face the conditioned room area.

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 UBC Standard 8-1.

EXCEPTIONS: 1. Foam plastic insulation shall comply with Section 2602 of the Uniform 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 707 of the Uniform 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: 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 Uniform Building Code Section 1505.3 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 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.

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.

EXCEPTION: Insulation may be omitted from floor areas over heated basements, heated garages or underfloor areas used as HVAC supply plenums. See Uniform Mechanical Code Section 607 for underfloor supply plenum requirements. 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.

502.1.4.8 Slab-On-Grade: Slab-on-grade insulation, installed inside the foundation wall, shall extend downward from the top of the slab for a minimum distance of 24 inches or downward and then horizontally beneath the slab for a minimum combined distance of 24 inches. Insulation installed outside the foundation shall extend downward to a minimum of 24 inches or to the frostline. 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.

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.

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.

EXCEPTIONS: 1. For glazed wall systems, assemblies with all of the following features are deemed to satisfy the vertical glazing U-factor requirement in Table 6-1 through 6-6 options with vertical glazing U-0.40 and greater:

a. Double glazing with a minimum 1/2 inch gap width, having a low-emissivity coating with e=0.10 maximum, with 90% minimum argon gas fill, and a non-aluminum spacer (as defined in footnote 1 to Table 10-6B), and

b. Frame that is thermal break aluminum (as defined in footnote 9 to Table 10-6B), wood, aluminum clad wood, vinyl, aluminum clad vinyl, or reinforced vinyl.

The only labeling requirement for products using this exception shall be a description of the product and a label stating: "This product is deemed to satisfy the Table 6-1 through 6-6 vertical glazing U-factor requirement using the exception to Section 502.1.5 in the Washington State Energy Code."

2. For overhead glazing, assemblies with all of the following features are deemed to satisfy the overhead glazing U-factor requirement in all Table 6-1 through 6-6 options **except** the unlimited glazing area options (Option VIII in Table 6-2, Option IX in Table 6-4, and Option VIII for Climate Zone 1 and Option IX for Climate Zone 2 in Table 6-6):

a. **Either**, double glazing with a minimum 1/2 inch gap width, having a low-emissivity coating with e=0.20 maximum, with 90% minimum argon gas fill,
or, triple glazed plastic domes, and

b. Frame that is thermal break aluminum (as defined in footnote 9 to Table 10-6B), wood, aluminum clad wood, vinyl, aluminum clad vinyl, or reinforced vinyl.

The only labeling requirement for products using this exception shall be a description of the product and a label stating: "This product is deemed to satisfy the Table 6-1 through 6-6 overhead glazing U-factor requirement using the exception to Section 502.1.5 in the Washington State Energy Code."

3. For solariums with a floor area which does not exceed 300 square feet, assemblies which comply with the features listed in Exception 2 are deemed to satisfy the vertical glazing and overhead glazing U-factor requirements in Table 6-1 through 6-6 options with vertical glazing U-0.40 and greater.

The only labeling requirement for products using this exception shall be a description of the product and a label stating: "This product is deemed to satisfy the Table 6-1 through 6-6 vertical glazing and overhead glazing U-factor requirements using the exception to Section 502.1.5 in the Washington State Energy Code."

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: Half-lite and full-lite doors, including fire doors, shall be assigned default U-factors from Table 10-6D. All other 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 either the U-factor or glazing area calculation requirements.

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.

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.

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 Group R Occupancy

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.

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 for all occupancies and all other openings in between units in R-1 occupancy 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 Lighting Fixtures: When installed in the building envelope, recessed lighting fixtures shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.
2. Type IC rated, installed inside a sealed box constructed from a minimum 1/2 inch thick gypsum wall board, or constructed from a preformed polymeric vapor barrier, or other air tight assembly manufactured for this purpose.
3. Type IC rated, 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.

SECTION 503 — BUILDING MECHANICAL SYSTEMS

503.1 General: This section covers the determination of design requirements, system and component performance, control requirements, insulating systems and duct construction.

> **EXCEPTION:** Special applications, including but not limited to hospitals, laboratories, thermally sensitive equipment and computer rooms may be exempted from the requirements of this section when approved by the building official.

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: Building mechanical systems for all buildings which provide space heating and/or space cooling shall be sized no greater than two hundred percent (200%) of the heating and cooling design loads as calculated above.

> **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 either the space heating or space cooling system size.
> 2. Natural gas- or oil-fired space heating equipment whose total rated space heating output in any one dwelling unit is 56,000 Btu/h or less may exceed the two hundred percent (200%) sizing limit provided that the installed equipment has an annual fuel utilization efficiency (AFUE) of not less than the sum of 78% plus 1% for every 5,000 Btu/h that the space heating equipment output exceeds the design heating load of the dwelling unit.
> 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.

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

503.4.1 Equipment Components

503.4.1.1 General: The requirements of this section apply to equipment and mechanical component performance for heating, ventilating and air conditioning systems. Equipment efficiency levels are specified. Data furnished by the equipment supplier or certified under a nationally recognized certification program or rating procedure shall be used to satisfy these requirements. Equipment efficiencies shall be based on the standard rating conditions in Tables 5-4, 5-5 or 5-6 as appropriate.

503.4.1.2 Assembled Components: Where components from more than one manufacturer are assembled into systems regulated under this section, compliance for each component shall be as specified in Sections 503.4.2 through 503.4.6 of this Code.

503.4.2 HVAC System Heating Equipment, Heat Pump, Heating Mode: Heat pumps whose energy input is entirely electric shall have a coefficient of performance (COP) heating, not less than the values in Table 5-7. Heat pumps with supplementary backup heat other than electricity shall meet the requirements of Table 5-7.

503.4.2.1 Application: These requirements apply to, but are not limited to, unitary (central) heat pumps (air source and water source) in the heating mode, water source (hydronic) heat pumps as used in multiple-unit hydronic HVAC systems, and heat pumps in the packaged terminal air conditioner in the heating mode.

503.4.2.2: Reserved

503.4.2.3 Supplementary Heater: The heat pump shall be installed with a control to prevent supplementary backup heater operation when the operating load can be met by the heat pump compression cycle alone.

503.4.2.4 Heat Pump Controls: Requirements for heat pump controls are listed in Section 503.8.3.5 of this Code.

503.4.3 HVAC System Combustion Equipment: For Group R Occupancy, all gas, oil, and propane central heating systems shall have a minimum AFUE of 0.78*. All other Group R Occupancy heating equipment fueled by gas, oil, or propane shall be equipped with an intermittent ignition device or shall comply with the efficiencies as required in the 1987 National Appliances Energy Conservation Act (Public Law 100-12).

* HVAC Heating system efficiency trade-offs shall be made using Chapters 4 or 6 of this Code.

503.4.4 Packaged and Unitary HVAC System Equipment, Electrically Operated, Cooling Mode: HVAC system equipment as listed below, whose energy input in the cooling mode is entirely electric, shall have an energy efficiency ratio (EER) or a seasonal energy efficiency ratio (SEER) cooling not less than values in Table 5-8.

503.4.4.1 Application: These requirements apply to, but are not limited to, unitary (central) and packaged terminal heat pumps (air source and water source); packaged terminal air conditioners.

503.4.5 Other HVAC Equipment: HVAC equipment, other than that addressed in Sections 503.4.2 through 503.4.4, shall have a minimum performance at the specified rating conditions not less than the values shown in Tables 14-1 through 14-3.

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 Section 1433.

503.8 Controls

503.8.1 Temperature Control: Each system shall be provided with at least one adjustable thermostat for the regulation of temperature. 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: Reserved

503.8.3.4 Control Setback and Shut-Off:

Residential Occupancy Groups. One- and Two-Family and Multifamily Dwellings--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.

503.7 Cooling with Outdoor Air (Economizer Cycle): ~~Systems and equipment that provide mechanical cooling shall comply with Section 1413 and, as appropriate, Section 1423 or Section 1433.~~ Each fan system shall be designed to use up to and including 100% of the fan system capacity for cooling with outdoor air automatically whenever its use will result in lower usage of new energy. Activation of economizer cycle shall be controlled by sensing outdoor air enthalpy or outdoor air dry-bulb temperature alone or alternate means approved by the building official.

EXCEPTIONS: Cooling with outdoor air is not required under any one or more of the following conditions:

1. The fan system capacity is less than 3,500 cfm or total cooling capacity is less than 90,000 Btu/h.
2. The quality of the outdoor air is so poor as to require extensive treatment of the air and approval by the building official.
3. The need for humidification or dehumidification requires the use of more energy than is conserved by the outdoor air cooling on an annual basis.
4. The use of outdoor air cooling may affect the operation of other systems so as to increase the overall energy consumption of the building.
5. When energy recovered from an internal/external zone heat recovery system exceeds the energy conserved by outdoor air cooling on an annual basis.
6. When all space cooling is accomplished by a circulating liquid which transfers space heat directly or indirectly to a heat rejection device such as a cooling tower without use of a refrigeration system.
7. When the use of 100% outside air will cause coil frosting, controls may be added to reduce the quantity of outside air. However, the intent of this exception is to use 100% air in lieu of mechanical cooling when less energy usage will result and this exception applies only to direct expansion systems when the compressor is running.

(Insert Facing Page 20)

503.8.3.5 Heat Pump Controls: Programmable thermostats are required for all heat pump systems. The cut-on temperature for the compression heating shall be higher than the cut-on temperature for the supplementary heat, and the cut-off temperature for the compression heating shall be higher than the cut-off temperature for the supplementary heat. Heat pump thermostats will be capable of providing at least two programmable setback periods per day. The automatic setback thermostat shall have the capability of limiting the use of supplemental heat during the warm-up period.

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 unvented crawl spaces with insulated walls, basements or cellars in one- and two-family dwellings.

503.10 Duct Construction: All duct work shall be constructed in accordance with Standards RS-15, RS-16, RS-17, RS-18, RS-19 or RS-20, as applicable, and the Uniform Mechanical Code.

503.10.1 Leakage Testing: High-pressure and medium-pressure ducts shall be leak tested in accordance with the applicable standards listed in Chapter 7 of this Code with the rate of air leakage not to exceed the maximum rate specified in that standard.

503.10.2 Seams and Joints: When low-pressure supply air ducts are located outside of the conditioned space, all HVAC ductwork seams and joints, both longitudinal and transverse, shall be taped and sealed with products approved by the building official only. Ductwork joints shall be mechanically fastened with a minimum of three fasteners per joint for a cylindrical duct. Use Table 5-11 for duct insulation requirements.

503.10.3 Dampers: Requirements for automatic or manual dampers are found in the Washington State Ventilation and Indoor Air Quality Code.

503.11 Piping Insulation: All piping installed to serve buildings (and within) shall be thermally insulated in accordance with Table 5-12. For service hot water systems see Section 504.7. If water pipes are outside of conditioned space then the pipe insulation requirement shall be R-3 minimum for non-recirculating hot and cold water pipes. For recirculating service hot and cold water pipes use Table 5-12 for pipe sizes and temperatures.

EXCEPTION: Piping insulation is not required within unitary HVAC equipment.

SECTION 504 -- SERVICE WATER HEATING

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 service water heating.

504.2 Water Heaters, Storage Tanks and Boilers

504.2.1 Performance Efficiency: All storage water heaters shall meet the requirements of the 1987 National Appliance Energy Conservation Act and be so labeled. 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 37 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 Pool Covers: Heated swimming pools shall be equipped with a pool cover, approved by the building official.

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

504.7 Pipe Insulation: For recirculating and non-recirculating systems, piping shall be thermally insulated in accordance with Section 503.11 and Table 5-12.

504.8 Conservation of Hot 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 showerheads or aerators to limit the total water flow rate as set forth in Chapter 51-46 WAC, as measured with both hot and cold faucets turned on to their maximum flow.

SECTION 505: Reserved

EQUATION 1 — GROUP R OCCUPANCY TARGET UA

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

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_{CC} = the thermal transmittance value of the cathedral ceiling area found in Table 5-1.

A_{CC} = cathedral 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 — GROUP R OCCUPANCY
PROPOSED UA

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

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_{CC}	=	the thermal transmittance of the cathedral ceiling area.
A_{CC}	=	cathedral 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:

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

EQUATION 4 — RESERVED

EQUATION 5 — RESERVED

TABLE 5-1
TARGET COMPONENT VALUES FOR GROUP R OCCUPANCY

Component	Electric Resistance Climate Zone 1	Electric Resistance Climate Zone 2	Other Fuels Climate Zone 1	Other Fuels Climate Zone 2
Glazing % Floor Area	15%	15%	15%	15%
Vertical Glazing U-Factor	U = 0.400	U = 0.400	U = 0.650	U = 0.600
Overhead Glazing U-Factor	U = 0.58	U = 0.58	U = 0.68	U = 0.64
Doors	U = 0.200 (R-5)	U = 0.200 (R-5)	U = 0.400 (R-2.5)	U = 0.400 (R-2.5)
Ceilings				
Attic	U = 0.031 (R-38)	U = 0.031 (R-38)	U = 0.036 (R-30)	U = 0.031 (R-38)
Single Rafter/Joist Vaulted	U = 0.034 (R-30)	U = 0.034 (R-30)	U = 0.034 (R-30)	U = 0.034 (R-30)
Walls	U = 0.058 (R-19A)	U = 0.044 (R-19+5A)	U = 0.062[1] (R-19)	U = 0.062[1] (R-19+5)
Floors	U = 0.029 (R-30)	U = 0.029 (R-30)	U = 0.041 (R-19)	U = 0.029 (R-30)
Slab on Grade Slab R-Value	F = 0.54 (R-10)	F = 0.54 (R-10)	F = 0.54 (R-10)	F = 0.54 (R-10)
Below Grade Interior				
Wall R-Value	R-19	R-19	R-19	R-19
2' Depth: Walls Slab	U = 0.043 F = 0.69	U = 0.043 F = 0.69	U = 0.043 F = 0.69	U = 0.043 F = 0.69
3.5' Depth: Walls Slab	U = 0.041 F = 0.64	U = 0.041 F = 0.64	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	U = 0.037 F = 0.57	U = 0.037 F = 0.57
Below Grade Exterior				
Wall R-Value	R-10	R-12	R-10	R-12
2' Depth: Walls Slab	U = 0.070 F = 0.60	U = 0.061 F = 0.60	U = 0.070 F = 0.60	U = 0.061 F = 0.60
3.5' Depth: Walls Slab	U = 0.064 F = 0.57	U = 0.057 F = 0.57	U = 0.064 F = 0.57	U = 0.057 F = 0.57
7' Depth: Walls Slab	U = 0.056 F = 0.42	U = 0.050 F = 0.42	U = 0.056 F = 0.42	U = 0.050 F = 0.42

1. Log and Solid Timber walls that have a minimum average thickness of 3.5" are exempt from wall target UA and proposed UA calculations.

TABLE 5-2 RESERVED

TABLE 5-3 RESERVED

TABLE 5-4
HVAC SYSTEM HEATING EQUIPMENT (HEAT PUMPS)
ELECTRICALLY OPERATED STANDARD RATING CONDITIONS

	TYPE		
CONDITIONS	Air Source		Water Source
Air entering equipment °F	70°F (dry bulb)	70°F (dry bulb)	70°F (dry bulb)
Outdoor unit ambient °F	47°F (dry bulb) /43°F (wet bulb)	17°F (dry bulb) /15°F (wet bulb)	----------
Entering water temp. °F	----------	----------	60°F
Water flow rate	----------	----------	As used in cooling

Standard ratings are at sea level.

TABLE 5-5
HVAC SYSTEM EQUIPMENT, ELECTRICALLY DRIVEN
STANDARD RATING CONDITIONS—COOLING

	TEMPERATURES			
	Dry Bulb	Wet Bulb	Inlet	Outlet
Air entering equipment °F	80°F	67°F	----	----
Condenser ambient (air cooled) °F	95°F	75°	----	----
Condenser water (water cooled) °F	----	----	85°F	95°F

Standard ratings are at sea level.

TABLE 5-6
APPLIED HVAC SYSTEM COMPONENTS ELECTRICALLY DRIVEN
STANDARD RATING CONDITIONS — COOLING

ITEM	Centrifugal or Self-Contained Reciprocating Water Chiller	Condenserless Reciprocating Water Chiller
Water Temperature, °F		
Leaving Chilled	44°	44°
Entering Chilled	54°	54°
Leaving Condenser	95°	---
Entering	85°	---
Fouling Factor, Water		
Nonferrous Tubes	0.0005*	0.0005
Steel Tubes	0.0010*	0.0010
Refrigerant	0.0000*	0.0000
Condenser Ambient, °F (air/evap. cooled)	95° (dry bulb) / 75° (wet bulb)	---
Compressor Saturated Discharge Temperature, °F		
Water Cooled (evap. cooled)	---	105°
Air Cooled	---	120°

Standard ratings at sea level.

* $h \cdot ft^2 \cdot °F/Btu$

TABLE 5-7
MINIMUM HEAT PUMP EFFICIENCIES, HEATING MODE[1]

SOURCE	MINIMUM COP	MINIMUM HSPF
Air Source:		
Split System	3.0[2]	6.8
Single Package System	3.0[2]	6.6
Water Source	3.8[3]	---
Ground Source	3.0[4]	---

1. When tested at the standard rating specified in Table 5-4.
2. When tested @ 47°F(dry bulb)/43°F(wet bulb)
3. @ 70°F entering
4. @ 50°F entering

TABLE 5-8
MINIMUM EFFICIENCY FOR ELECTRIC HVAC EQUIPMENT, COOLING

	Air Cooled		Evap/Water Cooled
Standard Rating Capacity	**SEER**	**EER**	**EER**
Under 65,000 Btu/h (19,050 watts)			
A. Split System	10.0	---	---
B. Single Package[3]	9.7	---	9.3[1]
65,000 Btu/h and over	---	8.9[2]	10.5[1]

1. @ 80°F (dry bulb) / 67°F (wet bulb)
2. @ 95°F dry bulb
3. Prior to January 1, 1993 a minimum value of 8.0 SEER may be used.

TABLE 5-9 RESERVED

TABLE 5-10 RESERVED

TABLE 5-11
INSULATION OF DUCTS

Duct Location	Climate Zone	Group R Occupancy 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.

2 Vapor barriers shall be installed on conditioned air supply ducts in geographic areas where the average of the July, August and September mean dewpoint temperature exceeds 60°F.

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.

V. Vapor barrier, with perm rating not greater than 0.5 perm, all joints sealed.

W. Approved weatherproof barrier.

TABLE 5-12
MINIMUM PIPE INSULATION REQUIREMENTS

Fluid Design Operating Temp. Range, °F	Insulation Conductivity		Nominal Pipe Diameter (in.)					
	Conductivity Range Btu • in./(h • ft² • °F)	Mean Rating Temp. °F	Runouts[2] up to 2	1 and less	> 1 to 2	> 2 to 4	> 4 to 6	> 6
Heating systems (Steam, Steam Condensate and Hot water)			Nominal Insulation Thickness					
Above 350	0.32-0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
251-350	0.29-0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
201-250	0.27-0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105-140	0.24-0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Domestic and Service Hot Water Systems								
105 and Greater	0.24-0.28	100	0.5	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine and Refrigerant)								
40-55	0.23-0.27	75	0.5	0.5	0.75	1.0	1.0	1.0
Below 40	0.23-0.27	75	1.0	1.0	1.5	1.5	1.5	1.5

1. Alternative Insulation Types. Insulation thicknesses in Table 5-12 are based on insulation with thermal conductivities within the range listed in Table 5-12 for each fluid operating temperature range, rated in accordance with ASTM C 335-84 at the mean temperature listed in the table. For insulation that has a conductivity outside the range shown in Table 5-12 for the applicable fluid operating temperature range at the mean rating temperature shown (when rounded to the nearest 0.01 Btu • in./(h • ft² • °F)), the minimum thickness shall be determined in accordance with the following equation:

$$T = PR[(1 + t/PR)^{K/k} - 1]$$

Where

T = Minimum insulation thickness for material with conductivity K, inches.
PR = Pipe actual outside radius, inches
t = Insulation thickness from Table 5-12, inches
K = Conductivity of alternate material at the mean rating temperature indicated in Table 5-12 for the applicable fluid temperature range, Btu • in/(h • ft² • °F)
k = The lower value of the conductivity range listed in Table 5-12 for the applicable fluid temperature range, Btu • in/(h • ft² • °F)

2. Runouts to individual terminal units not exceeding 12 ft. in length.

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 Group R Occupancies. Occupancies shall comply with all the requirements of Chapter 5 except for the modifications herein specified.

The building envelope requirements of this chapter may be met by installing one of the prescriptive packages in Tables 6-1 to 6-6. Installed components shall meet the requirements of Sections 602 and 605. 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.

SECTION 602 — BUILDING ENVELOPE REQUIREMENTS FOR GROUP R OCCUPANCY

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 Tables 6-1 to 6-6 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 Tables 6-1 to 6-6 as applicable. The following walls should be considered to meet R-19 without additional documentation:

1. 2 x 6 framed and insulated with R-19 fiberglass batts.
2. 2 x 4 framed and insulated with R-13 fiberglass batts plus R-3.2 foam sheathing.
3. 2 x 4 framed and insulated with R-11 fiberglass batts plus R-5.0 foam sheathing.

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 Tables 6-1 to 6-6 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 Tables 6-1 to 6-6 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 Tables 6-1 to 6-6.

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

EXCEPTIONS: 1. 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 Tables 6-1 to 6-6.

2. 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 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. Single glazing used for ornamental, security, or architectural purposes shall be calculated using the exception to Section 602.7.2.

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 Tables 6-1 to 6-6.

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 Tables 6-1 to 6-6. 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 Tables 6-1 to 6-6. 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: Single glazing for ornamental, security, or architectural purposes and double glazed garden windows with a wood or vinyl frame shall be

exempt from the U-factor calculations but shall have its area doubled and shall be included in the percentage of the total glazing area as allowed for in Tables 6-1 to 6-6. The maximum area (before doubling) allowed for the total of all single glazing and garden windows is 1% of the floor area.

602.8 Air Leakage for Group R Occupancy: The minimum air leakage control measures shall be as specified in Section 502.4 as applicable.

SECTION 603 — BUILDING MECHANICAL SYSTEMS FOR GROUP R OCCUPANCY

603.1: Group R Occupancies that are space heated by air-to-air, ground-to-air or water-to-air heat pumps shall comply with Table 6-2 or 6-4 or 6-6 for other fuels. System sizing shall be determined by an analysis consistent with Section 503.2 of this Code, or, when approved by the building official, Chapter 9. All mechanical equipment efficiencies and service water heating system efficiencies shall comply with standards as stated in Sections 503 and 504 of this Code.

TABLE 6-1
PRESCRIPTIVE REQUIREMENTS[1] FOR GROUP R OCCUPANCY
CLIMATE ZONE 1 • HEATING BY ELECTRIC RESISTANCE

Option	Glazing Area[10]: % of Floor	Glazing U-Factor		Door[9] U-Factor	Ceiling[2]	Vaulted Ceiling[3]	Wall Above Grade	Wall• int[4] Below Grade	Wall• ext[4] Below Grade	Floor[5]	Slab[4] on Grade
		Vertical	Overhead[11]								
I.	10%	0.46	0.58	0.40	R-38	R-30	R-21	R-21	R-10	R-30	R-10
II.	12%	0.43	0.58	0.20	R-38	R-30	R-19	R-19	R-10	R-30	R-10
III.	12%	0.40	0.58	0.40	R-38	R-30	R-21	R-21	R-10	R-30	R-10
IV.*	15%	0.40	0.58	0.20	R-38	R-30	R-19	R-19	R-10	R-30	R-10
V.	18%	0.39	0.58	0.20	R-38	R-30	R-21	R-21	R-10	R-30	R-10
VI.	21%	0.36	0.58	0.20	R-38	R-30	R-21	R-21	R-10	R-30	R-10
VII.[7]	25%	0.32[7]	0.58	0.20	R-38	R-30	R-19 +R-5[8]	R-21	R-10	R-30	R-10
VIII.[7]	30%	0.29[7]	0.58	0.20	R-38	R-30	R-19 +R-5[8]	R-21	R-10	R-30	R-10

* Reference Case

1. Minimum requirements for each option listed. For example, if a proposed design has a glazing ratio to the conditioned floor area of 19%, it shall comply with all of the requirements of the 21% 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. '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, or on the interior to the same level as walls above grade. 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.
7. The following options shall be applicable to buildings less than three stories: 0.35 maximum for glazing areas of 25% or less; 0.32 maximum for glazing areas of 30% or less.
8. This wall insulation requirement denotes R-19 wall cavity insulation plus R-5 foam sheathing.
9. Doors, including all fire doors, shall be assigned default U-factors from Table 10-6C or 10-6D.
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=0.40 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.

TABLE 6-2
PRESCRIPTIVE REQUIREMENTS[1] FOR GROUP R OCCUPANCY
CLIMATE ZONE 1 • HEATING BY OTHER FUELS

Option	HVAC[9] Equip. Effic.	Glazing Area[11]: % of Floor	Glazing U-Factor		Door [10] U-Factor	Ceiling[2]	Vaulted Ceiling[3]	Wall Above Grade	Wall• int[4] Below Grade	Wall• ext[4] Below Grade	Floor[5]	Slab[6] on Grade
			Vertical	Overhead[12]								
I.	Med.	10%	0.70	0.68	0.40	R-30	R-30	R-15	R-15	R-10	R-19	R-10
II.	Med.	12%	0.65	0.68	0.40	R-30	R-30	R-15	R-15	R-10	R-19	R-10
III.	High	21%	0.75	0.68	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
IV.*	Med.	21%	0.65	0.68	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
V.	Low	21%	0.60	0.68	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
VI.[7]	Med.	25%	0.45[7]	0.68	0.40	R-38	R-30	R-19	R-19	R-10	R-25	R-10
VII.[7]	Med.	30%	0.40[7]	0.68	0.40	R-30	R-30	R-19	R-19	R-10	R-25	R-10
VIII.	Med.	unlimited	0.25	0.40	0.40	R-30	R-30	R-19	R-19	R-10	R-25	R-10

* Reference Case

1. Minimum requirements for each option listed. For example, if a proposed design has a glazing ratio to the conditioned floor area of 19%, it shall comply with all of the requirements of the 21% 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. '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, or on the interior to the same level as walls above grade. 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.
7. The following options shall be applicable to buildings less than three stories: 0.50 maximum for glazing areas of 25% or less; 0.45 maximum for glazing areas of 30% or less.
8. This wall insulation requirement denotes R-19 wall cavity insulation plus R-5 foam sheathing.
9. Minimum HVAC equipment efficiency requirement. 'Low' denotes an AFUE of 0.74. 'Med.' denotes an AFUE of 0.78. 'High' denotes an AFUE of 0.88. Minimum HVAC equipment efficiency requirement for heat pumps. 'Low' denotes an HSPF of 6.35. 'Med.' denotes an HSPF of 6.8. 'High' an HSPF of 7.7. Water and ground source heat pumps shall be considered as medium efficiency and have a minimum COP as required in Table 5-7.
10. Doors, including all fire doors, shall be assigned default U-factors from Table 10-6C or 10-6D.
11. 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=0.40 or less is not included in glazing area limitations.
12. Overhead glazing shall have U-factors determined in accordance with NFRC 100 or as specified in Section 502.1.5.

TABLE 6-3
PRESCRIPTIVE REQUIREMENTS[1] FOR GROUP R OCCUPANCY
CLIMATE ZONE 2 • HEATING BY ELECTRIC RESISTANCE

Option	Glazing Area[11]: % of Floor	Glazing U-Factor		Door [10] U-Factor	Ceiling[2]	Vaulted Ceiling[3]	Wall Above Grade	Wall• int[4] Below Grade	Wall• ext[4] Below Grade	Floor[5]	Slab[6] on Grade
		Vertical	Overhead[12]								
I.	10%	0.38	0.58	0.20	R-38	R-30	R-21	R-21	R-12	R-30	R-10
II.	12%	0.40	0.58	0.20	R-38	R-30	R-19+R-5[8]	R-21	R-12	R-25	R-10
III.*	15%	0.40	0.58	0.20	R-38	R-30	R-19+R-5[8]	R-21	R-12	R-30	R-10
IV.	18%	0.38	0.58	0.20	R-38	R-30	R-19+R-5[8]	R-21	R-12	R-30	R-10
V.	21%	0.35	0.58	0.20	R-38Adv	R-38	R-19+R-5[8]	R-21	R-12	R-30	R-10
VI.[7]	25%	0.30[7]	0.58	0.20	R-49Adv	R-38	R-19+R-5[8]	R-21	R-12	R-30	R-10
VII.[7]	30%	0.28[7]	0.58	0.20	R-60Adv	R-38	R-21+R-7.5[9]	R-21	R-12	R-30	R-10

* Reference Case

1. Minimum requirements for each option listed. For example, if a proposed design has a glazing ratio to the conditioned floor area of 19%, it shall comply with all of the requirements of the 21% 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. '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 tbe exterior to a minimum level of R-12, or on the interior to the same level as walls above grade. 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.
7. The following options shall be applicable to buildings less than three stories: 0.33 maximum for glazing areas of 25% or less; 0.31 maximum for glazing areas of 30% or less.
8. This wall insulation requirement denotes R-19 wall cavity insulation plus R-5 foam sheathing.
9. This wall insulation requirement denotes R-21 wall cavity insulation plus R-7.5 foam sbeathing.
10. Doors, including all fire doors, shall be assigned default U-factors from Table 10-6C or 10-6D.
11. 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=0.40 or less is not included in glazing area limitations.
12. Overhead glazing shall have U-factors determined in accordance with NFRC 100 or as specified in Section 502.1.5.

TABLE 6-4
PRESCRIPTIVE REQUIREMENTS[1] FOR GROUP R OCCUPANCY
CLIMATE ZONE 2 • HEATING BY OTHER FUELS

Option	HVAC[9] Equip. Effic.	Glazing Area[11]:% of Floor	Glazing U-Factor		Door[10] U-Factor	Ceiling[2]	Vaulted Ceiling[3]	Wall Above Grade	Wall• int[4] Below Grade	Wall• ext[4] Below Grade	Floor[5]	Slab[6] on Grade
			Vertical	Overhead[12]								
I.	Med.	10%	0.70	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
II.	Med.	12%	0.65	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
III.	High	17%	0.65	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
IV.*	Med.	17%	0.60	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
V.	Low	17%	0.50	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VI.	Med.	21%	0.50	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VII.[7]	Med.	25%	0.40[7]	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VIII.[7]	Med.	30%	0.40[7]	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
IX.	Med.	unlimited	0.25	0.40	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10

* Reference Case

1. Minimum requirements for each option listed. For example, if a proposed design has a glazing ratio to the conditioned floor area of 19%, it shall comply with all of the requirements of the 21% 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. '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, or on the interior to the same level as walls above grade. 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.
7. The following options shall be applicable to buildings less than three stories: 0.45 maximum for glazing areas of 25% or less; 0.40 maximum for glazing areas of 30% or less.
8. This wall insulation requirement denotes R-19 wall cavity insulation plus R-5 foam sheathing.
9. Minimum HVAC equipment efficiency requirement. 'Low' denotes an AFUE of 0.74. 'Med.' denotes an AFUE of 0.78. 'High' denotes an AFUE of 0.88. Minimum HVAC equipment efficiency requirement for heat pumps. 'Low' denotes an HSPF of 6.35. 'Med.' denotes an HSPF of 6.8. 'High' an HSPF of 7.7. Water and ground source heat pumps shall be considered as medium efficiency and have a minimum COP as required in Table 5-7.
10. Doors, including all fire doors, shall be assigned default U-factors from Table 10-6C or 10-6D.
11. 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=0.40 or less is not included in glazing area limitations.
12. Overhead glazing shall have U-factors determined in accordance with NFRC 100 or as specified in Section 502.1.5.

TABLE 6-5
LOG HOMES PRESCRIPTIVE REQUIREMENTS[1]
HEATING BY ELECTRIC RESISTANCE

Option	Average[2] Log Thickness	Glazing Area[9]: % of Floor	Glazing U-Factor		Door [8] U-Factor	Ceiling[3]	Vaulted[4] Ceiling	Floor[5]	Slab[6] on Grade
			Vertical	Overhead[10]					
Climate Zone 1									
I.[7]	5.5"	15%	0.31	0.58	0.14	R-60 Adv	R-38	R-38	R-10
II.[7]	7.5"	15%	0.40	0.58	0.20	R-60 Adv	R-38	R-30	R-10
III.*	9.6"	15%	0.40	0.58	0.20	R-38	R-30	R-30	R-10
Climate Zone 2									
IV.[7]	6.7"	15%	0.31	0.58	0.14	R-60 Adv	R-38	R-38	R-10
V.[7]	8.7"	15%	0.40	0.58	0.14	R-60 Adv	R-38	R-38	R-10
VI.[7]	9.8"	15%	0.40	0.58	0.20	R-60 Adv	R-38	R-30	R-10
VII.[7]	10.5"	15%	0.40	0.58	0.20	R-49 Adv	R-38	R-30	R-10
VIII.*	13.5"	15%	0.40	0.58	0.20	R-38	R-30	R-30	R-10

* Reference Case

1. For Group R Occupancy use Table 6-5 for only the portion of floor area using log/solid timber walls. Use Tables 6-1 to 6-4 for all other portions of the floor area. Minimum requirements are for each option listed. Interpolations between options is not permitted. 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. Required minimum average log thickness.
3. 'Adv' denotes Advanced Framing. Requirement applies to all ceilings except single rafter joist vaulted ceilings.
4. Requirement applicable only to single rafter joist vaulted ceilings.
5. Floors over crawl spaces or exposed to ambient air conditions.
6. Required slab perimeter insulation shall be water resistant material, manufactured for its intended use, and installed according to manufacturer's specifications.
7. These options shall be applicable to buildings less than three stories.
8. Doors, including all fire doors, shall be assigned default U-factors from Table 10-6C or 10-6D.
9. 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=0.40 or less is not included in glazing area limitations.
10. Overhead glazing shall have U-factors determined in accordance with NFRC 100 or as specified in Section 502.1.5.

TABLE 6-6
LOG HOMES PRESCRIPTIVE REQUIREMENTS[1]
HEATING BY OTHER FUELS

Option	HVAC[9] Equip. Effic.	Glazing Area[12]: % of Floor	Glazing U-Factor		Door[10] U-Factor	Ceiling[2]	Vaulted Ceiling[3]	Wall[11] Above Grade	Wall•int[4] Below Grade	Wall•ext[4] Below Grade	Floor[5]	Slab[6] on Grade
			Vertical	Overhead[13]								
Climate Zone 1												
I.	Med.	10%	0.70	0.68	0.40	R-30	R-30	R-15	R-15	R-10	R-19	R-10
II.	Med.	12%	0.65	0.68	0.40	R-30	R-30	R-15	R-15	R-10	R-19	R-10
III.	High	21%	0.75	0.68	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
IV.*	Med.	21%	0.65	0.68	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
V.	Low	21%	0.60	0.68	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
VI.[7]	Med.	25%	0.45[7]	0.68	0.40	R-38	R-30	R-19	R-19	R-10	R-25	R-10
VII.[7]	Med.	30%	0.40[7]	0.68	0.40	R-30	R-30	R-19	R-19	R-10	R-25	R-10
VIII.	Med.	unlimited	0.25	0.40	0.40	R-30	R-30	R-19	R-19	R-10	R-25	R-10
Climate Zone 2												
I.	Med.	10%	0.70	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
II.	Med.	12%	0.65	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
III.	High	17%	0.65	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
IV.*	Med.	17%	0.60	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
V.	Low	17%	0.50	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VI.	Med.	21%	0.50	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VII.	Med.	25%	0.40[8]	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VIII.	Med.	30%	0.40[8]	0.64	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
IX.	Med.	unlimited	0.25	0.40	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10

* Reference Case

1. Minimum requirements for each option listed. For example, if a proposed design has a glazing ratio to the conditioned floor area of 19%, it shall comply with all of the requirements of the 21% 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. '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, or on the interior to the same level as walls above grade. 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.
7. The following options shall be applicable to buildings less than three stories: 0.50 maximum for glazing areas of 25% or less; 0.45 maximum for glazing areas of 30% or less.
8. The following options shall be applicable to buildings less than three stories: 0.45 maximum for glazing areas of 25% or less; 0.40 maximum for glazing areas of 30% or less.
9. Minimum HVAC equipment efficiency requirement. 'Low' denotes an AFUE of 0.74. 'Med.' denotes an AFUE of 0.78. 'High' denotes an AFUE of 0.88. Minimum HVAC equipment efficiency requirement for heat pumps. 'Low' denotes an HSPF of 6.35. 'Med.' denotes an HSPF of 6.8. 'High' an HSPF of 7.7. Water and ground source heat pumps shall be considered as medium efficiency and have a minimum COP as required in Table 5-7.
10. Doors, including all fire doors, shall be assigned default U-factors from Table 10-6C or 10-6D.
11. Log and solid timber walls with a minimum average thickness of 3.5" are exempt from this insulation requirement.
12.. 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=0.40 or less is not included in glazing area limitations.
13. Overhead glazing shall have U-factors determined in accordance with NFRC 100 or as specified in Section 502.1.5.

TABLE 6-7 RESERVED

CHAPTER 7
STANDARDS

SECTION 701 — STANDARDS

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	1997 ASHRAE Fundamentals Handbook.
RS-2 - RS-3:	(Reserved.)
RS-4	ASHRAE Standard 55-92 Thermal Environmental Conditions for Human Occupancy.
RS-5 - RS-8:	(Reserved.)
RS-9	ASHRAE Standard 90.1-1989, Efficient Design of New Buildings Except New Low-Rise Residential Buildings.
RS-10	Standard for Packaged Terminal Air Conditioners and Heat Pumps, ARI Standard 310/380-93.
RS-11	1995 ASHRAE HVAC Applications Handbook.
RS-12 - RS-14:	(Reserved.)
RS-15	1996 ASHRAE Systems and Equipment Handbook.
RS-16	SMACNA, Installation Standards for Residential Heating and Air Conditioning Systems, 6th Edition, 1988.
RS-17	SMACNA, HVAC Duct Construction Standards Metal and Flexible, 2nd Edition, 1995.
RS-18	Same as Standard RS-17.
RS-19	SMACNA, Fibrous Glass Duct Construction Standards, 6th Edition, 1992.
RS-20	1994 ASHRAE Refrigeration Handbook.
RS-21	Same as Standard RS-10.
RS-22 - RS-24:	(Reserved.)
RS-25	Thermal Bridge in Sheet Metal Construction from Appendix E of Standard RS-9.
RS-26	Super Good Cents Technical Reference.

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

ARI refers to the Air Conditioning 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

IES refers to the Illuminating Engineering Society, 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., 1300 Spring Street, Suite 500, Silver Spring, Maryland 20910
Phone (301) 589-NFRC Fax (301) 588-0854, Internet www.nfrc.org

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

CHAPTER 8
SUGGESTED SOFTWARE FOR CHAPTER 4
SYSTEMS ANALYSIS APPROACH FOR GROUP R OCCUPANCY

CALPAS 3
BSG Software
40 Lincoln Street
Lexington, Mass 02173
(617) 861-0109

DOE 2
ACROSOFT/CAER Engineers
1204-½ Washington Avenue
Golden, CO 80401
(303) 279-8136

F-LOAD
F-CHART SOFTWARE
4406 Fox Bluff Rd.
Middleton, WI 53562
(608) 836-8531

MICROPAS
ENERCOMP
1721 Arroyo Drive
Auburn, CA 95603
(800) 755-5903

SUNDAY
ECOTOPE
2812 East Madison St.
Seattle, WA 98112
(206) 322-3753

WATTSUN 5.6
WSU Extension Seervice
925 Plum Street
Building 4
Olympia, WA 98504-3165
(360) 956-2000

CHAPTER 9
PRESCRIPTIVE HEATING SYSTEM SIZING

When using the prescriptive approach in Chapter 6, if approved by the building official, design heat load calculations are not required to show compliance to this Code if the heating system installed is equal to or less than the following:

Climate Zone 1	
Electric Resistance	21 Btu/h•ft^2
Electric Resistance (Forced Air)	24 Btu/h•ft^2
Other Fuels (Forced Air)	27 Btu/h•ft^2

Climate Zone 2	
Electric Resistance	29 Btu/h•ft^2
Electric Resistance (Forced Air)	32 Btu/h•ft^2
Other Fuels (Forced Air)	39 Btu/h•ft^2

Example: A 1500 ft^2 house in Zone 1, heated with gas, would not have to submit a design heat load if the proposed furnace is 40,500 Btu or less.

$$1500 \times 27 = 40{,}500$$

Disclaimer: All heating systems shall be designed and installed in accordance with Uniform Building Code Section 310.11.

CHAPTER 10
DEFAULT HEAT LOSS COEFFICIENTS

SECTION 1001 — GENERAL

1001.1 Scope: 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-26, 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-26, listed in Chapter 7, are used, along with data from the sources referenced above.

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•°F per square foot of wall area). Coefficients for below-grade slabs are listed as F-factors (Btu/h•°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 10-1
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/°F•hr 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•ft²•°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.

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 – CRAWLSPACE FLOORS

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

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 150 feet of perimeter. The crawlspace is assumed to be 2-1/2 feet high, with 24 inches below grade and 6 inches above grade.

1004.2 Crawlspace Description: Four crawlspace configurations are considered: vented, unvented, enclosed and heated plenum.

Vented crawlspaces: Assumed to have 3 air changes per hour, with at least 1 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.

Unvented crawlspaces: Assumed to have 1.5 air changes per hour, with less than 1 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.

Enclosed 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.

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.

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 R-value	U-factor		
	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 lists heat loss coefficients for the opaque portion of above-grade walls (Btu/h•ft^2•°F). They are derived from procedures listed in Standard RS-1, listed in Chapter 7, assuming exterior air films at 7.5-mph wind speed.

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.

1005.2 Framing Description: 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 3 studs and each opening is framed using 2 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 2 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 2 studs or other means of fully insulating corners, and each opening is framed by 2 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 2 studs or other means of fully insulating corners, and 1 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 four types of walls are listed: single-stud walls, metal stud walls, strap walls and double-stud walls.

Single-Stud Wall: 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.

Metal Stud Wall: 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.

Strap Wall: 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: 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.

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

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

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

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

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

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

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

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

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

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

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

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

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

Stress Skin Panel

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

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

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

TABLE 10-5A
Overall Assembly U-Factors for Metal Stud Walls

Metal Framing	R-Value of Continuous Foam Board Insulation	Cavity Insulation					
		R-11	R-13	R-15	R-19	R-21	R-25
16" o.c.	R-0 (none)	U-0.14	U-0.13	U-0.12	U-0.10	U-0.097	U-0.091
	R-1	U-0.12	U-0.12	U-0.11	U-0.094	U-0.089	U-0.083
	R-2	U-0.11	U-0.010	U-0.099	U-0.086	U-0.081	U-0.077
	R-3	U-0.10	U-0.095	U-0.090	U-0.079	U-0.075	U-0.071
	R-4	U-0.091	U-0.087	U-0.082	U-0.073	U-0.070	U-0.067
	R-5	U-0.083	U-0.080	U-0.076	U-0.068	U-0.065	U-0.062
	R-6	U-0.077	U-0.074	U-0.071	U-0.064	U-0.061	U-0.059
	R-7	U-0.071	U-0.069	U-0.066	U-0.060	U-0.058	U-0.055
	R-8	U-0.067	U-0.064	U-0.062	U-0.057	U-0.055	U-0.053
	R-9	U-0.062	U-0.060	U-0.058	U-0.054	U-0.052	U-0.050
	R-10	U-0.059	U-0.057	U-0.055	U-0.051	U-0.049	U-0.048
24" o.c	R-0 (none)	U-0.13	U-0.12	U-0.11	U-0.091	U-0.085	U-0.079
	R-1	U-0.11	U-0.10	U-0.098	U-0.084	U-0.078	U-0.073
	R-2	U-0.10	U-0.091	U-0.089	U-0.077	U-0.073	U-0.068
	R-3	U-0.092	U-0.083	U-0.082	U-0.072	U-0.068	U-0.064
	R-4	U-0.084	U-0.077	U-0.076	U-0.067	U-0.063	U-0.060
	R-5	U-0.078	U-0.071	U-0.070	U-0.063	U-0.060	U-0.057
	R-6	U-0.072	U-0.067	U-0.066	U-0.059	U-0.056	U-0.054
	R-7	U-0.067	U-0.063	U-0.062	U-0.056	U-0.053	U-0.051
	R-8	U-0.063	U-0.059	U-0.058	U-0.053	U-0.051	U-0.048
	R-9	U-0.059	U-0.056	U-0.055	U-0.050	U-0.048	U-0.046
	R-10	U-0.056	U-0.053	U-0.052	U-0.048	U-0.046	U-0.044

SECTION 1006 -- DEFAULT U-FACTORS FOR GLAZING AND DOORS

1006.1 Untested Glazing and Doors: Untested glazing and doors shall be assigned the U-factors from Tables 10-6A, 10-6B, 10-6C, 10-6D, or 10-6E as appropriate.

TABLE 10-6A
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
	Tripie,	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
DEFAULT U-FACTORS FOR VERTICAL GLAZING FOR SMALL BUSINESSES[1]

DESCRIPTION[2,3,4,5,6]	FRAME TYPE[7,8]			
	ALUMINUM	ALUM. THERMAL BREAK[9]	WOOD/VINYL	ALUM. CLAD WOOD/REINFORCED VINYL[10]
Double, Clear ¼"	0.82	0.66	0.56	0.59
Double, Clear ¼" + argon	0.77	0.63	0.53	0.56
Double, Low-e4 ¼"	0.76	0.61	0.52	0.54
Double, Low-e2 ¼"	0.73	0.58	0.49	0.51
Double, Low-e1 ¼"	0.70	0.55	0.47	0.49
Double, Low-e4 ¼" + argon	0.70	0.55	0.47	0.49
Double, Low-e2 ¼" + argon	0.66	0.52	0.43	0.46
Double, Low-e1 ¼" + argon	0.64	0.50	0.41	0.43
Double, Clear 3/8"	0.78	0.63	0.54	0.57
Double, Clear 3/8" + argon	0.75	0.60	0.51	0.54
Double, Low-e4 3/8"	0.72	0.57	0.48	0.51
Double, Low-e2 3/8"	0.69	0.54	0.45	0.48
Double, Low-e1 3/8"	0.66	0.51	0.43	0.46
Double, Low-e4 3/8" + argon	0.68	0.53	0.44	0.47
Double, Low-e2 3/8" + argon	0.63	0.49	0.41	0.44
Double, Low-e1 3/8" + argon	0.61	0.47	0.39	0.41
Double, Clear ½"	0.75	0.60	0.50	0.54
Double, Clear ½" + argon	0.72	0.58	0.48	0.51
Double, Low-e4 ½"	0.68	0.53	0.44	0.47
Double, Low-e2 ½"	0.64	0.50	0.41	0.44
Double, Low-e1 ½"	0.61	0.47	0.39	0.42
Double, Low-e4 ½" + argon	0.65	0.50	0.42	0.44
Double, Low-e2 ½" + argon	0.60	0.46	0.37	0.40
Double, Low-e1 ½" + argon	0.58	0.43	0.35	0.38
Triple, Clear ¼"	0.66	0.52	0.42	0.44
Triple, Clear ¼" + argon	0.63	0.49	0.39	0.42
Triple, Low-e4 ¼"	0.64	0.50	0.40	0.40
Triple, Low-e2 ¼"	0.62	0.48	0.39	0.41
Triple, Low-e1 ¼"	0.61	0.47	0.38	0.40
Triple, Low-e4 ¼" + argon	0.60	0.46	0.37	0.39
Triple, Low-e2 ¼" + argon	0.58	0.43	0.34	0.37
Triple, Low-e1 ¼" + argon	0.57	0.42	0.34	0.36
Triple, Clear ½"	0.61	0.46	0.37	0.40
Triple, Clear ½" + argon	0.59	0.45	0.36	0.38
Triple, Low-e4 ½"	0.58	0.43	0.35	0.37
Triple, Low-e2 ½"	0.55	0.41	0.32	0.35
Triple, Low-e1 ½"	0.54	0.39	0.31	0.33
Triple, Low-e4 ½" + argon	0.55	0.41	0.32	0.35
Triple, Low-e2 ½" + argon	0.52	0.38	0.30	0.32
Triple, Low-e1 ½" + argon	0.51	0.37	0.29	0.31

Footnotes to Table 10-6B

1. Subtract 0.02 from the listed default U-factor for non-aluminum spacer. Acceptable spacer materials may include but is not limited to fiberglass, wood and butyl or other material with an equivalent thermal performance.
2. 1/4" = a minimum dead air space of 0.25 inches between the panes of glass. 3/8" = a minimum dead air space of 0.375 inches between the panes of glass. 1/2"= a minimum dead air space of 0.5 inches between the panes of glass.

   Product with air spaces different than those listed above shall use the value for the next smaller air space; i.e. 3/4 inch = 1/2 inch U-factors, 7/16 inch = 3/8 inch U-factors, 5/16 inch = 1/4 inch U-factors.
3. Low-e4 (emissivity) shall be 0.4 or less. Low-e2 (emissivity) shall be 0.2 or less. Low-e1 (emissivity) shall be 0.1 or less.
4. U-factors listed for argon shall consist of sealed, gas-filled insulated units for argon, CO2, SF6, and argon/SF6 mixtures. The following conversion factor shall apply to Krypton gas-filled units: 1/4" or greater with krypton is equivalent to 1/2" argon.
5. Dividers placed between glazing: The U-factor listed shall be used where the divider has a minimum gap of 1/8 inch between the divider and lite of each inside glass surface. Add 0.03 to the listed U-factor for True Divided Lite windows.
6. "Glass block" assemblies may use a U-factor of 0.51.
7. Insulated fiberglass framed products shall use wood/vinyl U-factors.
8. Subtract 0.02 from the listed default values for solariums.
9. 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.
10. Aluminum clad wood windows shall use the U-factors listed for Aluminum Clad Wood/Reinforced Vinyl windows. Vinyl clad wood window shall use the U-factors listed for Wood/Vinyl windows. Any vinyl frame window with metal reinforcement in more than one rail shall use the U-factors listed for Aluminum Clad Wood/Reinforced Vinyl window.

TABLE 10-6C
TRANSMISSION COEFFICIENTS (U) FOR WOOD AND STEEL DOORS
Btu/h•ft²•F

Nominal Door Thickness, Inches	Description	No Storm Door	Wood Storm Door[c]	Metal Storm Door[d]
Wood Doors[b]				
1-3/8	Panel door with 7/16 inch panels[e]	0.57	0.33	0.37
1-3/8	Hollow core flush door	0.47	0.30	0.32
1-3/8	Solid core flush door	0.39	0.26	0.28
1-3/4	Panel door with 7/16 inch panels[e]	0.57	0.33	0.36
1-3/4	Hollow core flush door	0.46	0.29	0.32
1-3/4	Panel door with 3/4 inch panels[e]	0.40	0.27	0.29
1-3/4	Panel door with 1-1/8 inch panels[e]	0.39	0.26	0.28
1-3/4	Solid core flush door	0.33	0.28	0.25
2-1/4	Solid core flush door	0.27	0.20	0.21
Steel Doors[b]				
1-3/4	Fiberglass or mineral wool core with steel stiffeners, no thermal break[f]	0.60	---	---
1-3/4	Paper honeycomb core without thermal break[f]	0.56	---	---
1-3/4	Solid urethane foam core without thermal break[a]	0.40	---	---
1-3/4	Solid fire rated mineral fiberboard core without thermal break[f]	0.38	---	---
1-3/4	Polystyrene core without thermal break (18 gage commercial steel)[f]	0.35	---	---
1-3/4	Polyurethane core without thermal break (18 gage commercial steel)[f]	0.29	---	---
1-3/4	Polyurethane core without thermal break (24 gage commercial steel)[f]	0.29	---	---
1-3/4	Polyurethane core with thermal break & wood perimeter (24 gage commercial steel)[f]	0.20	---	---
1-3/4	Solid urethane foam core with thermal break	0.19	0.16	0.17

NOTE: All U-factors for exterior doors in this table are for doors with no glazing, except for the storm doors which are in addition to the main exterior door. Any glazing area in exterior doors should be included with the appropriate glass type and analyzed. Interpolation and moderate extrapolation are permitted for door thicknesses other than those specified.

a. Values are based on a nominal 32 by 80 in. door size with no glazing.
b. Outside air conditions: 15 mph wind speed, 0°F air temperature; inside air conditions: natural convection, 70°F air temperature.
c. Values for wood storm door are for approximately 50% glass area.
d. Values for metal storm door are for any percent glass area.
e. 55% panel area.
f. ASTM C 236 hotbox data on a nominal 3 by 7 ft door size with no glazing.

The U-factors in Table 6C are for exterior wood and steel doors. The values given for wood doors were calculated, and those for steel doors were taken from hotbox tests (Sabine et al. 1975: Yellot 1965) or from manufacturer's test reports. An outdoor surface conductance of 6.0 Btu/h•ft²•°F was used, and the indoor surface conductance was taken as 1.4 Btu/h•ft²•°F for vertical surfaces with horizontal heat flow. All values given are for exterior doors without glazing. If an exterior door contains glazing, refer to Table 10-6D.

TABLE 10-6D
APPROVED GLAZED DOOR DEFAULT U-FACTORS[1]

Description[2,3,4,5]	Door Material			
	Insulated[6]		Wood[7]	
	Full-Lite[4,9]	Half-Lite[10,11]	Full-Lite[3]	Half-Lite[10]
Double, Clear 1/4"	0.39	0.31	0.47	0.42
Double, Clear 1/4" + argon	0.37	0.30	0.45	0.41
Double, Low-e4 1/4"	0.36	0.30	0.44	0.41
Double, Low-e2 1/4"	0.35	0.29	0.43	0.40
Double, Low-e1 1/4"	0.24	0.28	0.41	0.39
Double, Low-e4 1/4" + argon	0.33	0.28	0.41	0.39
Double, Low-e2 1/4" + argon	0.31	0.26	0.39	0.38
Double, Low-e1 1/4" + argon	0.31	0.26	0.38	0.37
Double, Clear 3/8"	0.37	0.30	0.45	0.41
Double, Clear 3/8" + argon	0.36	0.29	0.44	0.41
Double, Low-e4 3/8"	0.34	0.28	0.42	0.40
Double, Low-e2 3/8"	0.33	0.28	0.41	0.39
Double, Low-e1 3/8"	0.21	0.26	0.38	0.37
Double, Low-e4 3/8" + argon	0.32	0.27	0.40	0.38
Double, Low-e2 3/8" + argon	0.29	0.25	0.37	0.37
Double, Low-e1 3/8" + argon	0.29	0.25	0.36	0.36
Double, Clear 1/2"	0.36	0.29	0.44	0.41
Double, Clear 1/2" + argon	0.34	0.28	0.42	0.40
Double, Low-e4 1/2"	0.32	0.27	0.40	0.38
Double, Low-e2 1/2"	0.30	0.26	0.38	0.37
Double, Low-e1 1/2"	0.29	0.25	0.36	0.36
Double, Low-e4 1/2" + argon	0.30	0.26	0.38	0.37
Double, Low-e2 1/2" + argon	0.28	0.25	0.36	0.36
Double, Low-e1 1/2" + argon	0.28	0.24	0.34	0.35
Triple, Clear 1/4"	0.31	0.26	0.39	0.38
Triple, Clear 1/4" + argon	0.29	0.25	0.37	0.37
Triple, Low-e4 1/4"	0.30	0.26	0.38	0.37
Triple, Low-e2 1/4"	0.29	0.25	0.37	0.36
Triple, Low-e4 1/4" + argon	0.27	0.24	0.35	0.35
Triple, Low-e2 1/4" + argon	0.26	0.24	0.34	0.35

1. Subtract 0.02 from the listed default U-factor for insulated spacers. Insulated spacer material includes fiberglass, wood and butyl or other material with an equivalent Thermal performance.
2. 1/4" = a minimum dead air space of 0.25 inches between the panes of glass. 3/8" = a minimum dead air space of 0.375 inches between the panes of glass. 1/2" = a minimum dead air space of 0.5 inches between the panes of glass. Products with air spaces different than those listed above shall use the value for next smaller air space; i.e. 3/4 inch = 1/2 inch U-factors, 7/16 inch = 3/8 inch U-factors, 5/16 inch = 1/4 inch U-factors.
3. Low-e4 (emissivity) shall be 0.4 or less. Low-e2 (emissivity) shall be 0.2 or less. Low-e1 (emissivity) shall be 0.1 or less.
4. U-factors listed for argon shall consist of sealed, gas-filled, insulated units for argon, CO2, SF6 and argon/SF6 mixtures. The following conversion factor shall apply to Krypton gas-filled units: 1/4 inch or greater airspace of Krypton gas-fill = 1/2 inch air space Argon gas-fill.
5. Dividers placed between glazing: The U-factors listed shall be used where the divider has a minimum gap of 1/8 inch between the divider and lite of each inside glass surface. Add 0.03 to the listed U-factor for True Divided Lite windows.
6. Insulated = Any urethane insulated foam core door with a thermal break. Thermal Break = A thermal break door shall incorporate the following design characteristics:
   a) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h•ft^2•°F; and
   b) The thermal break material shall not be less than 0.210 inches.
7. Wood = any wood door.
8. Full-Lite = A door that consists of more than 50% glazing.
9. Add 0.05 to the listed U-factor for Full-Lite values if the insulated door does not have a thermal break.
10. Half-Lite = A door that consists of 50% or less glazing.
11. Add 0.06 to the listed U-factor for Half-Lite values if the insulated door does not have a thermal break.

TABLE 10-6E
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 9 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.

1007.2 Component Description: The three 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 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.

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.

TABLE 10-7
DEFAULT U-FACTORS FOR CEILINGS

Ceilings Below Vented Attics

	Standard Frame	Advanced Frame
Flat Ceiling	**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_0

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_0 with R-3 Sheathing[2]

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_0 with R-5 Sheathing[2]

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_0 with R-10 Sheathing[2]

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_0 with R-15 Sheathing[2]

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.

SECTION 1008 -- AIR INFILTRATION

1008.1 General: Tables 10-8 and 10-9 list effective air change rates and heat capacities for heat loss due to infiltration.

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). 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 10-9
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: Table 10-10 lists default mass-values for residential construction types. All calculations are based on standard ASHRAE values for heat-storage capacity as listed in Standard RS-1, Chapter 24.

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 10-10
DEFAULT MASS VALUES

Structural Mass M-value	**Btu/ft²• °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/ft²• °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

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 of new or altered buildings and structures or portions thereof that provide facilities or shelter for public assembly, educational, business, mercantile, institutional, storage, factory, and industrial occupancies by regulating their exterior envelopes and the selection of their HVAC, service water heating, 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.

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 Building Mechanical Systems: Those parts of systems which are altered or replaced shall comply with Chapter 14 of this Code.

1132.3 Lighting and Motors: Tenant improvements, alterations or repairs where 60% or more of the fixtures are new shall comply with Sections 1531 and 1532. Where less than 60% of the fixtures are new, the installed lighting wattage shall be maintained or reduced. Where 60% 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. Where a new lighting panel with all new raceway and conductor wiring from the panel to the fixtures is being installed, controls shall comply with Section 1513.6.

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 Group R Occupancy which is converted to other than a Group R Occupancy 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.

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 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; 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.

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 108.5 of the Uniform Building Code. Inspections may be conducted by special inspection pursuant to Section 1701 of the Uniform 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 Uniform 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.

CHAPTER 12
DEFINITIONS

SECTION 1201 – SCOPE

The following definitions will apply to Chapters 11 through 20.

SECTION 1210 – 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 bave 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 2007.2 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 2005.2 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.

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

ARI: Air-Conditioning and Refrigeration Institute.

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: Walls or the portion of walls which are entirely below the finished grade or which extend two feet or less above the finish grade.

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 ENVELOPE: The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior, or to or from unconditioned spaces, or 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.

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.

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 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 daylighting zone depth is assumed to extend into the space a distance of 15 feet 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.

DESIGN COOLING CONDITIONS: The cooling outdoor design temperature from the 0.5% column for summer from the Puget Sound Chapter of ASHRAE publication "Recommended Outdoor Design Temperatures, Washington State, ASHRAE."

DESIGN HEATING CONDITIONS: The heating outdoor design temperature from the 0.6% column for winter from the Puget Sound Chapter of ASHRAE publication "Recommended Outdoor Design Temperatures, Washington State, ASHRAE."

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

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.

DWELLING UNIT: See the Washington State Building Code.

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.

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.

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**.)

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

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.

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.

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

F-VALUE: (See **F-Factor**.)

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% 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. (See **Below Grade Wall.**)

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 un-insulated 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 2 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 heated by a heating system

a. 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; and

b. is not a Heated Space (Fully Heated).

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.)

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.

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.

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**.)

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 as specified by the manufacturer according to recognized trade and engineering standards.

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

NONRESIDENTIAL: All buildings and spaces in the Uniform Building Code (UBC) occupancies other than Group R.

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.

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-10.)

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-96-72 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 FLOOR: A 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.

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 (excluding minerals) 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.

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 28 of Standard RS-27, listed in Chapter 17 of this Code.

SHALL: Denotes a mandatory Code requirement.

SKYLIGHT: (See **Overhead Glazing.**)

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.

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 2005.2 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 • ft^2 • °F).

THERMAL RESISTANCE (R): The reciprocal of thermal conductance (h • ft^2 • °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 • ft^2 • °F).

THERMAL TRANSMITTANCE, OVERALL (U_O): The overall (average) heat transmission of a gross area of the exterior building envelope (Btu/h • ft^2 • °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.

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

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

UNCONDITIONED SPACE: Space within a building that is not a conditioned space. (See **Conditioned Space.**)

UNIFORM BUILDING CODE (UBC): (See **Washington State Uniform Building Code.**)

UNIFORM MECHANICAL CODE (UMC): (See **Washington State Uniform Mechanical Code.**)

UNIFORM PLUMBING CODE (UPC): (See **Washington State Uniform Plumbing Code.**)

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.

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 with the horizontal plane, and separates conditioned from unconditioned space. Band joists between floors are to be considered a part of exterior walls.

WASHINGTON STATE UNIFORM BUILDING CODE (UBC): The Uniform Building Code as modified by the Washington State Building Code Council.

WASHINGTON STATE UNIFORM MECHANICAL CODE (UMC): The Uniform Mechanical Code as modified by the Washington State Building Code Council.

WASHINGTON STATE UNIFORM PLUMBING CODE (UPC): The Uniform Plumbing Code as modified by the Washington 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 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 M occupancy accessory to Group R occupancy.

4. Unstaffed equipment shelters or cabinets used soley 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: Climate Zone 2 shall include: 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). Heating shall be controlled by a thermostat mounted not lower than the heating unit and capable of preventing heating above 44° space temperature. For semi-heated spaces, the only prescriptive, component performance or systems analysis building envelope requirement shall be that:

Climate Zone 1

a. U=0.10 maximum for the roof assembly, or

b. continuous R-9 insulation installed entirely outside of the roof structure, or

c. R-11 insulation installed inside or within a wood roof structure, or

d. R-19 insulation installed inside or within a metal roof structure.

Climate Zone 2

a. U=0.07 maximum for the roof assembly, or

b. continuous R-14 insulation installed entirely outside of the roof structure, or

c. R-19 insulation installed inside or within a wood roof structure, or

d. R-25 insulation installed inside or within a metal roof structure.

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

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: 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 frostline, 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 Section 2006.

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 29 of Standard RS-27 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. Roof/ceiling assemblies without a vented airspace, where neither the roof deck nor the roof structure are made of wood, shall provide a continuous vapor retarder with taped seams.

EXCEPTION: Vapor retarders need not be provided where all of the insulation is installed between the roof membrane and the structural roof deck.

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 Crawl Spaces: 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.

1314 Air Leakage

1314.1 Building Envelope: The requirements of this section shall apply to building elements separating conditioned from unconditioned spaces. 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 shall be sealed, caulked, gasketed or weatherstripped to limit air leakage.

1314.2 Glazing and Doors: Doors and operable glazing separating conditioned from unconditioned space shall be weatherstripped. Fixed windows shall be tight fitting with glass retained by stops with sealant or caulking all around.

EXCEPTION: Openings that are required to be fire resistant.

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.

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.

EXCEPTIONS: 1. Opaque smoke vents are not required to meet insulation requirements.

2. The perimeter edge of an above grade floor slab which penetrates the exterior wall may be left uninsulated provided that the wall insulation is increased by R-2 above that required in Tables 13-1 and 13-2.

1323 Glazing: Glazing shall comply with Section 1312 and Tables 13-1 or 13-2. All glazing shall be, at a minimum, double glazing.

EXCEPTIONS: 1. Vertical glazing located on the street level story of a retail occupancy provided the glazing is double-glazed with a minimum 1/2 inch airspace and does not exceed 75% of the gross exterior wall area of the street level story which does not exceed 20 feet in height. 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 ornamental, security or architectural purposes 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.

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: For buildings or structures utilizing the other space heat type (including heat pumps and VAV) compliance path, for the gross opaque wall, opaque door and glazing (vertical and overhead) area only, compliance may also be shown using the ENVSTD diskette version 2.1 or later of Standard RS-9, or an approved alternative, with the following additional requirements:

1. Only the Exterior Wall Requirements portion of the ENVSTD computer program may be used under this exception.
2. Overhead glazing shall be added to vertical glazing, and shall be input as 1/4 north, 1/4 east, 1/4 south, and 1/4 west facing.
3. Lighting loads shall be determined according to Table 15-1.
4. Equipment loads shall be determined from Table 3-1 of Standard RS-29.

1332 Component U-Factors: The U-factors for typical construction assemblies are included in Chapter 20. These values shall be used for all calculations. Where proposed construction assemblies are not represented in Chapter 20, values shall be calculated in accordance with Chapters 21 through 29 in Standard RS-27 listed in Chapter 17, using the framing factors listed in Chapter 20. 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-25, listed in Chapter 17, 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 24 of Standard RS-27, listed in Chapter 17.

4. Effective framing/cavity R-values as provided in Table 20-5A.

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.

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EQUATION 13-1
Target UA_t

$$UA_t = U_{rat}A_{rat} + U_{ograt}A_{ograt} + U_{ort}A_{ort} + U_{ogort}A_{ogort} + U_{wt}A_{wt} + U_{vgt}A_{vgt} + U_{dt}A_{dt} + U_{ft}A_{ft} + F_{st}P_{st} + U_{bgwt}A_{bgwt}$$

UA_t = The target combined specific heat transfer of the gross roof/ceiling assembly, exterior wall and floor area.

Where:

U_{rat} = The thermal transmittance value for roofs over attics found in Table 13-1 or 13-2.

U_{ograt} = The thermal transmittance for overhead 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.

U_{ort} = The thermal transmittance value for other roofs found in Table 13-1 or 13-2.

U_{ogort} = The thermal transmittance for overhead 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.

U_{wt} = The thermal transmittance value for opaque walls found in Table 13-1 or 13-2.

U_{vgt} = The thermal transmittance value for vertical 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.

U_{dt} = The thermal transmittance value for opaque doors found in Table 13-1 or 13-2.

U_{ft} = The thermal transmittance value for floors over unconditioned space found in Table 13-1 or 13-2.

F_{st} = The F-factor for slab-on-grade and radiant slab floors found in Table 13-1 or 13-2.

U_{bgwt} = The thermal transmittance value for opaque walls found in Table 13-1 or 13-2.

A_{dt} = The proposed opaque door area, A_d.

A_{ft} = The proposed floor over unconditioned space area, A_f.

P_{st} = The proposed lineal feet of slab-on-grade and radiant slab floor perimeter, P_s.

A_{bgwt} = The proposed below grade wall area, A_{bgw}.

and;

if the total amount of glazing area as a percent of gross exterior wall area does not exeed the maximum allowed in Table 13-1 or 13-2:

A_{rat} = The proposed roof over attic area, A_{ra}.

A_{ograt} = The proposed overhead glazing area in roofs over attics, A_{ogra}.

A_{ort} = The proposed other roof area, A_{or}.

A_{ogort} = The proposed overhead glazing area in other roofs, A_{ogor}.

A_{wt} = The proposed opaque above grade wall area, A_w.

A_{vgt} = The proposed vertical glazing area, A_{vg}.

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:

A_{rat} = The greater of:
the proposed roof over attic area, and
the gross roof over attic area minus A_{ograt}.

A_{ograt} = The lesser of:
proposed overhead glazing area in roofs over attics, and
the maximum allowed glazing area from Table 13-1 or 13-2.

A_{ort} = The greater of:
the proposed other roof area, and
the gross other roof area minus A_{ogort}.

A_{ogort} = The lesser of:
the proposed overhead glazing area in other roofs, and
the maximum allowed glazing area from Table 13-1 or 13-2 minus A_{ograt}.

A_{wt} = The greater of:
proposed opaque above grade wall area, and
the gross exterior above grade wall area minus A_{dt} minus A_{vgt}.

A_{vgt} = The lesser of:
the proposed vertical glazing area, and
the maximum allowed glazing area from Table 13-1 or 13-2 minus A_{ograt} minus A_{ogort}.

EQUATION 13-2
Proposed UA_p

$$UA_p = U_{ra}A_{ra} + U_{or}A_{or} + U_{og}A_{og} + U_wA_w + U_dA_d + U_{vg}A_{vg} + U_fA_f + F_sP_s + U_{bgw}A_{bgw}$$

Where:

UA_p = The combined proposed specific heat transfer of the gross exterior wall, floor and roof/ceiling assembly area.

U_{ra} = The thermal transmittance of the roof over attic area.

A_{ra} = Opaque roof over attic area.

U_{or} = The thermal transmittance of the other roof area.

A_{or} = Opaque other roof area.

U_{og} = The thermal transmittance for the overhead glazing.

A_{og} = Overhead glazing area.

U_w = The thermal transmittance of the opaque wall area.

A_w = Opaque above grade wall area (not including opaque doors).

U_{vg} = The thermal transmittance of the vertical glazing area.

A_{vg} = Vertical glazing area.

U_d = The thermal transmittance value of the opaque door area.

A_d = Opaque door area.

U_f = The thermal transmittance of the floor over unconditioned space area.

A_f = Floor area over unconditioned space.

F_s = Slab-on-grade or radiant floor component F-factor.

P_s = Lineal feet of slab-on-grade or radiant floor perimeter.

U_{bgw} = The thermal transmittance value of the below grade wall area.

A_{bgw} = Below grade wall area as defined in Tables 13-1 or 13-2.

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:

$$U_{w1}A_{w1} + U_{w2}A_{w2} + U_{w3}A_{w3} + \ldots\text{etc.}$$

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
MINIMUM INSULATION R-VALUES OR MAXIMUM COMPONENT U-FACTORS FOR ZONE 1

Building Components

Space Heat Type	Components					
	Roofs Over Attic	All Other Roofs	Opaque Walls[1,2]	Opaque Doors	Floor Over Uncond Space	Slab On Grade[5]
1. Electric resistance heat	R-38 or U=0.031	R-30 or U=0.034	R-19 or U=0.062[3]	U=0.60	R-30 or U=0.029	R-10 or F=0.54
2. All others including heat pumps and VAV	R-30 or U=0.036	R-21 or U=0.050	R-11 or U=0.14	U=0.60	R-19 or U=0.056	R-10 or F=0.54

MAXIMUM GLAZING AREAS AND U-FACTORS AND MAXIMUM GLAZING SOLAR HEAT GAIN COEFFICIENTS FOR ZONE 1

Glazing

Maximum Glazing Area as % of Wall	0% to 15%			>15% to 20%			>20% to 30%			>30% to 40%		
	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]
	VG	OG		VG	OG		VG	OG		VG	OG	
1. Electric resistance heat	0.40	0.80	1.0	0.40	0.80	1.0	PRESCRIPTIVE PATH NOT ALLOWED					
2. All others including heat pumps and VAV	0.90	1.45	1.0	0.75	1.40	1.0	0.60	1.30	0.65	0.50	1.25	0.45

Footnotes

1. **Below Grade Walls:**
   When complying by the prescriptive approach, Section 1322:
   a) walls insulated on the interior shall use opaque wall values,
   b) walls insulated on the exterior shall use a minimum of R-10 insulation,
   c) those portions of below grade walls and footings that are more than 10 feet below grade, and not included in the gross exterior wall area, may be left uninsulated.

   When complying by the component performance approach, Section 1331:
   a) walls insulated on the interior shall use the opaque wall values when determining U_{bgwt} ,
   b) walls insulated on the exterior shall use a target U-factor of U=0.070 for U_{bgwt} ,
   c) those portions of below grade walls and footings that are more than 10 feet below grade, and not included in the gross exterior wall area, need not be included when determining A_{bgwt} and A_{bgw}.

2. **Concrete Masonry Walls:** If the area weighted heat capacity of the total opaque above grade wall is a minimum of 9.0 Btu/ft² • °F, then the U-factor may be increased to 0.19 for interior insulation and 0.25 for integral and exterior insulation for insulation position as defined in Chapter 12. Individual walls with heat capacities less than 9.0 Btu/ft² • °F and below grade walls shall meet opaque wall requirements listed above. Glazing shall comply with the following:

Maximum Glazing Area as % of Wall	0 to 10 %			>10 to 15 %			>15% to 20 %			>20% to 25 %		
	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]
	VG	OG		VG	OG		VG	OG		VG	OG	
1. Electric resistance heat	0.40	0.80	1.0	0.40	0.80	1.0	0.40	0.80	1.0	NOT ALLOWED		
2. All others including heat pumps and VAV	0.90	1.45	1.0	0.75	1.40	1.0	0.65	1.30	0.80	0.60	1.30	0.65

3. **Metal Stud Walls:** For metal stud construction U=0.11.
4. **SHGC (Solar Heat Gain Coefficient per Section 1312.2):** May substitute Maximum Shading Coefficient (SC) for SHGC (See Section 1210 for definition of Shading Coefficient).
5. **Radiant Floors:** Where insulation is required under the entire slab, radiant floors shall use a minimum of R-10 insulation or F=0.55 maximum. Where insulation is not required under the entire slab, radiant floors shall use R-10 perimeter insulation according to Section 1311.6 or F=0.78 maximum.

TABLE 13-2
BUILDING ENVELOPE REQUIREMENTS FOR CLIMATE ZONE 2

MINIMUM INSULATION R-VALUES OR MAXIMUM COMPONENT U-FACTORS FOR ZONE 2

Building Components

Space Heat Type	Components					
	Roofs Over Attic	All Other Roofs	Opaque Walls[1,2]	Opaque Doors	Floor Over Uncond Space	Slab On Grade[5]
1. Electric resistance heat	R-38 or U=0.031	R-30 or U=0.034	R-24 or U=0.044[3]	U=0.60	R-30 or U=0.029	R-10 or F=0.54
2. All others including heat pumps and VAV	R-38 or U=0.031	R-25 or U=0.040	R-19 or U=0.11	U=0.60	R-21 or U=0.047	R-10 or F=0.54

MAXIMUM GLAZING AREAS AND U-FACTORS AND MAXIMUM GLAZING SOLAR HEAT GAIN COEFFICIENTS FOR ZONE 2

Glazing

Maximum Glazing Area as % of Wall	0% to 15%			>15% to 20%			>20% to 25%			>25% to 30%		
	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]
	VG	OG		VG	OG		VG	OG		VG	OG	
1. Electric resistance heat	0.40	0.80	1.0	0.40	0.80	1.0	PRESCRIPTIVE PATH NOT ALLOWED					
2. All others including heat pumps and VAV	0.90	1.45	1.0	0.75	1.40	1.0	0.60	1.30	0.60	0.50	1.25	0.50

Footnotes

1. **Below Grade Walls:**
   When complying by the prescriptive approach, Section 1322:
   a) walls insulated on the interior shall use opaque wall values,
   b) walls insulated on the exterior shall use a minimum of R-12 insulation,
   c) those portions of below grade walls and footings that are more than 10 feet below grade, and not included in the gross exterior wall area, may be left uninsulated.

   When complying by the component performance approach, Section 1331:
   a) walls insulated on the interior shall use the opaque wall values when determining U_{bgwt} ,
   b) walls insulated on the exterior shall use a target U-factor of U=0.061 for U_{bgwt} ,
   c) those portions of below grade walls and footings that are more than 10 feet below grade, and not included in the gross exterior wall area, need not be included when determining A_{bgwt} and A_{bgw}.

2. **Concrete Masonry Walls:** If the area weighted heat capacity of the total opaque above grade wall is a minimum of 9.0 Btu/ft² • °F, then the U-factor may be increased to 0.19 for interior insulation and 0.25 for integral and exterior insulation for insulation position as defined in Chapter 12. Individual walls with heat capacities less than 9.0 Btu/ft² • °F and below grade walls shall meet opaque wall requirements listed above. Glazing shall comply with the following:

Maximum Glazing Area as % of Wall	0 to 5 %			>5 to 7 %			>7% to 10 %			>10% to 15 %		
	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]	Maximum U-Factor		Max. SHGC[4]
	VG	OG		VG	OG		VG	OG		VG	OG	
1. Electric resistance heat	0.40	0.80	1.0	0.40	0.80	1.0	0.40	0.80	1.0	NOT ALLOWED		
2. All others including heat pumps and VAV	0.90	1.45	1.0	0.60	1.30	0.7	0.50	1.25	0.50	0.40	0.80	0.40

3. **Metal Stud Walls**: For metal stud construction U=0.10.
4. **SHGC (Solar Heat Gain Coefficient per Section 1312.2):** May substitute Maximum Shading Coefficient (SC) for SHGC (See Section 1210 for definition of Shading Coefficient).
5. **Radiant Floors:** Where insulation is required under the entire slab, radiant floors shall use a minimum of R-10 insulation or F=0.55 maximum. Where insulation is not required under the entire slab, radiant floors shall use R-10 perimeter insulation according to Section 1311.6 or F=0.78 maximum.

CHAPTER 14
BUILDING MECHANICAL SYSTEMS

1401 Scope: This section covers the determination of requirements, system and component performance, control requirements and duct construction.

> **EXCEPTION:** Special applications, including but not limited to hospitals, laboratories, thermally sensitive equipment and rooms designed to comply with the special construction and fire protection requirements of NFPA 75, "Standard for the Protection of Electronic Computer/Data Processing Equipment" may be exempt from the requirements of this section when approved by the building official. Exemptions shall be specific on a case-by-case basis and allowed only to the extent necessary to accommodate the special applications.

1402 Mechanical Ventilation: The minimum requirements for ventilation shall comply with the Washington State Ventilation and Indoor Air Quality Code (WAC 51-13).

SECTION 1410 – GENERAL REQUIREMENTS

The building mechanical system shall comply with Sections 1411 through 1415, Sections 1440 through 1442 and Sections 1450 through 1454, and with one of the following paths:

a. Simple Systems (Packaged Unitary Equipment) Sections 1420 through 1424.

b. Complex Systems Sections 1430 through 1438.

c. Systems Analysis. See Section 1141.4.

Figure 14A
Mechanical Systems Compliance Paths

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
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	
RS-29	Systems Analysis			X
1440	Service Water Heating	X	X	X
1441	Water Heater Installation	X	X	X
1442	Shut Off Controls	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

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 14-1 through 14-3.

1411.2 Rating Conditions: Cooling equipment shall be rated at ARI test conditions and procedures when available. Where no applicable procedures exist, data shall be furnished by the equipment manufacturer.

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.

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.

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. Buildings complying with Section 1141.4, if in the proposed building energy analysis, heating and cooling thermostat setpoints are set to the same temperature between 70°F and 75°F inclusive, and assumed to be constant throughout the year.

3. 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 have a minimum seven-day clock and be capable of being set for seven different day types per week.

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.

1412.4.1 Dampers: Outside air intakes, exhaust outlets and relief outlets serving conditioned spaces shall be equipped with dampers which close automatically when the system is off or upon power failure.

EXCEPTIONS: 1. Systems serving areas which require continuous operation.

2. Combustion air intakes.

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).

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.

1413 Air Economizers

1413.1 Operation: Air economizers shall be 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.

1413.2 Control: Air economizers shall be controlled by a control system capable of determining if outside air can meet part or all of the building's cooling loads.

1413.3 Integrated Operation - Building Heating Energy: Air economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load. Controls shall not preclude the economizer operation when mechanical cooling is required simultaneously.

EXCEPTION: Economizers on individual, direct expansion, cooling systems with capacities not greater than 75,000 Btu/h may include controls that limit simultaneous operation of the economizer and mechanical cooling for the purpose of preventing ice formation on cooling coils.

1414 Ducting Systems

1414.1 Sealing: Duct work which is designed to operate at pressures above 1/2 inch water column static pressure shall be sealed in accordance with Standard RS-18. Extent of sealing required is as follows:

1. Static pressure: 1/2 inch to 2 inches; seal transverse joints.

2. Static pressure: 2 inches to 3 inches; seal all transverse joints and longitudinal seams.

3. Static pressure: above 3 inches; seal all transverse joints, longitudinal seams and duct wall penetrations.

Duct tape and other pressure sensitive tape shall not be used as the primary sealant where ducts are designed to operate at static pressures of 1 inch W.C. or greater.

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 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.

Once outside air ducts meet the above listed requirements, any runs within conditioned space must 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 space that serves that space only.

1415 Piping Systems

1415.1 Insulation: Piping shall be thermally insulated in accordance with Table 14-6.

EXCEPTION: Piping installed within unitary HVAC equipment.

Water pipes outside the conditioned space shall be insulated in accordance with Washington State Plumbing Code (WAC 51-46)

SECTION 1420 – SIMPLE SYSTEMS (Packaged Unitary Equipment)

1421 System Type: To qualify as a simple system, systems 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.

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 5,000 cfm or which have a minimum outside air supply of less than 70% of the total air circulation.

All other systems shall comply with Sections 1430 through 1438.

1422 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.

1423 Economizers: Economizers meeting the requirements of Section 1413 shall be installed on single package unitary fan-cooling units having a supply capacity of greater than 1,900 cfm or a total cooling capacity greater than 54,000 Btu/h.

The total capacity of all units without economizers shall not exceed 240,000 Btu/h per building, or 10% of its aggregate cooling (economizer) capacity, whichever is greater.

1424 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 1438. Simple systems may also comply with Sections 1430 through 1438.

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.

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 or by outside air temperature. Temperature shall be reset by at least 25% of the design supply-air-to-room-air temperature difference.

> **EXCEPTION:** Where specified humidity levels are required to satisfy process needs, such as computer rooms or museums.

1432.2.2 Hydronic Systems: Systems with a design capacity of 600,000 Btu/h or greater supplying heated water to comfort conditioning systems shall include controls which automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature. Temperature shall be reset by at least 25% of the design supply-to-return water temperature differences.

1433 Economizers: Economizers meeting the requirements of Section 1413 shall be installed on the following systems:

a. Single package unitary fan-cooling units with a supply capacity of greater than 1,900 cfm or a total cooling capacity greater than 54,000 Btu/h.

b. Other individual fan-cooling units with a supply capacity of greater than 2,800 cfm or a total cooling capacity greater than 84,000 Btu/h.

The total capacity of all units without economizers shall not exceed 240,000 Btu/h per building, or 10% of its aggregate cooling (economizer) capacity, whichever is greater.

> **EXCEPTIONS:** 1. Systems with air or evaporatively cooled condensers and that either one of the following can be demonstrated to the satisfaction of the enforcing agency:
>
> a. Special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants, makes an air economizer infeasible.
>
> b. The use of outdoor air cooling affects the operation of other systems (such as humidification, dehumidification and supermarket refrigeration systems) so as to increase the overall building energy consumption.
>
> 2. Systems for which at least 75% of the annual energy used for mechanical cooling is provided from site-recovery or site-solar energy source.
>
> 3. A water economizer system, which is capable of cooling supply air by indirect evaporation. Such a system shall be designed and capable of being controlled to provide 100% of the expected system cooling load 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 air temperatures.

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 than 25% of the total system supply air, or
> 2. The total conditioned floor area of the zones is less than 1,000 ft^2.

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, for all air in excess of that required by the Washington State Ventilation and Indoor Air Quality Code (WAC 51-13) or by mechanical refrigeration.

d. Other simultaneous operation of heating and cooling systems to the same zone.

EXCEPTIONS: 1. Variable air volume systems which have fan-powered terminal units on the perimeter zones controlled to utilize plenum heat prior to new energy being used for morning warm-up; and which, during periods of occupancy, are designed to reduce the air supply to each zone to a minimum before reheating, recooling or mixing takes place. The minimum volume of air from the main supply duct shall be no greater than the minimum required to meet ventilation requirements of the Washington State Ventilation and Indoor Air Quality Code (WAC 51-13).

2. Zones having special pressurization relationships or cross-contamination requirements.

3. Where at least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.

4. Zones where specific humidity levels are required.

5. Zones with a peak supply air quantity of 300 cfm or less.

1436 Heat Recovery: Fan systems which have both a capacity of 5,000 cfm or greater and which have a minimum outside air supply of 70% or greater of the total air circulation 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. Provision 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.

EXCEPTIONS: 1. Laboratory systems equipped with both variable air volume supply and variable air volume or two-speed exhaust fume hoods.

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.

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 14-1 and 14-2 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.

1438 Variable Flow Systems: For fans and pumps greater than 10 hp, where the application involves variable flow, there shall be variable frequency drives or variable flow devices installed. Acceptable variable flow devices include variable inlet vanes, variable blade pitch and variable fan geometry. Throttling valves (dampers), scroll dampers or bypass circuits shall not be allowed.

SECTION 1440 — SERVICE WATER HEATING

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.

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 Reserved.

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: 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.

TABLE 14-1
Standard Rating Conditions and Minimum Performance for Air Cooled Unitary Air Conditioners, Heat Pumps, Packaged Terminal Air Conditioners, Warm Air Furnaces, Duct Furnaces and Unit Heaters

Equipment Type & Rating	Category	Sub-category & Rating Conditions	Minimum Rating		Standard
			Steady State	Seasonal or Part Load	
Air Conditioners and Heat Pumps Cooling Ratings	≤65,000 Btu/h Cooling Capacity	Split Systems Single Package	NA NA	10.0 SEER 9.7 SEER	ARI 210/240-1989
	>65,000 & ≤135,000 Btu/h Cooling Capacity	All Unitary Standard Ratings:	8.9 EER 95°F db	8.3 IPLV 80°F db	
	>135,000 & ≤760,000 Btu/h[1] Cooling Capacity	Air Conditioners Heat Pumps	8.5 EER 8.5 EER	7.5 IPLV 7.5 IPLV	ARI 360-1986
	>760,000 Btu/h[1] Cooling Capacity	Air Conditioners Heat Pumps	8.2 EER 8.7 EER	7.5 IPLV 7.5 IPLV	
Packaged Term. Air Conditioners & Heat Pumps Cooling Ratings	All Capacities	Air Conditioners and Heat Pumps Standard/Low Temp:	10.0 - (0.16 x Cap/1000)[3] EER 95°F	12.2 - (0.20 x Cap/1000)[2,3] EER 82°F	ARI 310-1990
Heat Pump Heating Ratings	≤65,000 Btu/h Cooling Capacity	Split Systems Single Package		6.8 HSPF 6.6 HSPF	ARI 210/240-1989
	>65,000 & ≤135,000 Btu/h Cooling Capacity	All Unitary Standard Ratings:	3.0 COP 47°F db/43°F wb	2.0 COP 17°F db/15°F wb	
	>135,000 Btu/h Cooling Capacity	Standard Ratings:	2.9 COP 47 °F	2.0 COP 17 °F	ARI 365-1986
Packaged Term. Heat Pumps Heating Ratings	All Capacities	Heat Pumps Standard Ratings:	2.9 - (0.026xCap/1000)[3] COP 47°F db/43°F wb		ARI 380-1990
Warm Air Furnaces & Combination Furnace/A.C.	<225,000 Btu/h	Gas and Oil Fired Seasonal Ratings:	80% E_t[4]	78% AFUE[5]	DOE 10CFR Part430 AppN
	≥225,000 Btu/h	Gas, Max Rating[6] Gas, Min Rating[6]	80% E_t[4] 78% E_t[4]	NA NA	ANSI Z21.47-1983
	≥225,000 Btu/h	Oil, Max Rating[6] Oil, Min Rating[6]	81% E_t[4] 81% E_t[4]	NA NA	UL 727-1986
Warm Air Duct Furnaces and Unit Heaters	All Size Gas Duct Furnaces	Max Rated Capacity[6] Min Rated Capacity[6]	78% E_t[4] 75% E_t[4]	NA NA	ANSI Z83.9-1986
	All Size Gas Unit Heaters	Max Rated Capacity[6] Min Rated Capacity[6]	78% E_t[4] 74% E_t[4]	NA NA	ANSI Z83.8-1985
	All Size Oil Unit Heaters	Max Rated Capacity[6] Min Rated Capacity[6]	81% E_t[4] 81% E_t[4]	NA NA	UL 731-1988

1. For units that have a heating section, deduct 0.2 from all required EER's and IPLV's.
2. For multi-capacity equipment the minimum performance shall apply to each step provided multi-capacity refers to manufacturer published rating for more than one capacity mode allowed by the product's controls.
3. Capacity (Cap) means the rated cooling capacity of the product in Btu/h in accordance with the cited ARI standard. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
4. These values apply to non-NAECA equipment. See referenced standard for definition of thermal efficiency (Et), (100% - flue losses).
5. To be consistent with National Appliance Energy Conservation Act (NAECA) of 1987 (Public Law 100-12). These values apply to furnace and combination units covered by NAECA.
6. Minimum and maximum ratings as provided for and allowed by the unit's controls.

TABLE 14-2
Standard Rating Conditions and Minimum Performance for Water and Evaporatively Cooled Unitary Air Conditioners, Heat Pumps, Water Source and Ground Source Heat Pumps, Condensing Units, and Water Chilling Packages

Equipment Type & Rating	Category	Sub-category & Rating Conditions	Minimum Rating		Standard
			Steady State	Seasonal or Part Load	
Evaporatively Cooled A/Cs & Heat Pumps Cooling Ratings	≤65,000 Btu/h Cooling Capacity	Standard Conditions[1]: Outdoor Conditions: 95°F db/75°F wb	9.3 EER	8.5 IPLV	ARI 210/240-1989
	>65,000 and ≤135,000 Btu/h Cooling Capacity		10.5 EER	9.7 IPLV	CTI 201-1986
Water Source Heat Pump Cooling Ratings	≤65,000 Btu/h Cooling Capacity	Standard Conditions[1]: Entering Water	9.3 EER 85°F ewt[2]	10.2 EER 75°F ewt[2]	ARI 320-1986
	>65,000 and ≤135,000 Btu/h Cooling Capacity	Standard Conditions[1]: Entering Water	10.5 EER 85°F ewt[2]	NA	CTI 201-1986
Ground Water Heat Pump Cooling Ratings	<135,000 Btu/h Cooling Capacity	Standard Conditions[1]: Entering Water	11.0 EER 70°F ewt[2]	11.5 EER 50°F ewt[2]	ARI 325-1985
Water Cooled Unitary Air Conditioners Cooling Ratings	≤65,000 Btu/h Cooling Capacity	Standard Conditions[1]: Entering Water	9.3 EER 85°F ewt[2]	8.3 IPLV 75°F ewt[2]	ARI 210/240-1989
	>65,000 and ≤135,000 Btu/h Cooling Capacity	Standard Conditions[1]: Entering Water	10.5 EER 85°F ewt[2]	NA	CTI 201-1986
Water/Evap. Cooled Air Cond. and Heat Pumps Cooling Ratings	>135,000 Btu/h Cooling Capacity	Standard Conditions[1]:	9.6 EER	9.0 IPLV	ARI 360-1986 CTI 201-1986
Air and Water/ Evap. Cooled Condensing Units Cooling Ratings[3]	>135,000 Btu/h Cooling Capacity	Air Cooled	9.9 EER	11.0 IPLV	ARI 365-1987
		Water/Evap. Cooled	12.9 EER	12.9 IPLV	CTI 201-1986
Air and Water Cooled Water Chilling Packages Cooling Ratings	<150 Tons	Water Cooled	3.8 COP	3.9 IPLV	ARI 550-90 ARI 590-86pN CTI 201-1986
	≥150 and <300 Tons		4.2 COP	4.5 IPLV	
	≥300 Tons		5.2 COP[4]	5.3 IPLV[4]	
	<150 Tons	Air Cooled With Condenser	2.7 COP	2.8 IPLV	
	≥150 Tons		2.5 COP	2.5 IPLV	
	All Capacities	Air Cooled Condenserless	3.1 COP	3.2 IPLV	
Water & Ground-Water Source Heat Pumps Heating Ratings	<135,000 Btu/h Cooling Capacity	Water Source Standard Conditions[1]:	3.8 COP 70°F ewt[2]	NA NA	ARI 320-1986
		Ground Water Source Standard Conditions[1]:	3.4 COP 70°F ewt[2]	3.0 COP 50°F ewt[2]	ARI 325-1985

1. Standard Indoor Conditions: 80°F dry bulb and 67°F wet bulb.
2. ewt: Entering Water Temperature for water cooled heat pumps and air conditioners.
3. Condensing unit requirements are based on single-number rating defined in paragraph 5.1.3.2 of ARI Standard 365.
4. These requirements are reduced to 4.7 COP and 4.8 IPLV, where refrigerants with ozone depletion factors of 0.05 or less are used. No reduction is allowed for standard design systems analyzed under Standard RS-29.

TABLE 14-3
Standard Rating Conditions and Minimum Performance, Gas- and Oil-Fired Boilers

Reference	Category	Rating Condition	Minimum Performance
DOE Test Procedure 10 CFR, Part 430 AppN	Gas-Fired <300,000 Btu/h	Seasonal Rating	AFUE 80%[1,3]
	Oil-Fired <300,000 Btu/h	Seasonal Rating	AFUE 80%[1]
ANSI Z21.13-87 H.I. Htg. Boiler Std. 86 ASME PTC4.1-64 U.L. 795-73	Gas-Fired ≥300,000 Btu/h	1. Max. Rated Capacity[2] Steady-State	E_c[4] 80%
		2. Min. Rated Capacity[2] Steady-State	E_c[4] 80%
U.L. 726-75 H.I. Htg. Boiler Std. 86 ASME PTC4.1-64	Oil-Fired ≥300,000 Btu/h	1. Max. Rated Capacity[2] Steady-State	E_c[4] 83%
		2. Min. Rated Capacity[2] Steady-State	E_c[4] 83%
H.I. Htg. Boiler Std. 86 ASME PTC4.1-64	Oil-Fired (Residual) ≥300,000 Btu/h	1. Max. Rated Capacity[2] Steady-State	E_c[4] 83%
		2. Min. Rated Capacity[2] Steady-State	E_c[4] 83%

1. To be consistent with National Appliance Energy Conservation Act of 1987 (P.L. 100-12).
2. Provided and allowed by the controls.
3. Except for gas-fired steam boilers for which minimum AFUE is 75%.
4. E_c = combustion efficiency, 100% - flue losses. See reference document for detailed information.

TABLE 14-4
Energy Efficient Electric Motors
Minimum Nominal Full-Load Efficiency

	Open Motors			Closed Motors		
Synchronous Speed (RPM)	3,600	1,800	1,200	3,600	1,800	1,200
HP	Efficiency	Efficiency	Efficiency	Efficiency	Efficiency	Efficiency
1.0	-	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2.0	84.0	84.0	85.5	84.0	84.0	86.5
3.0	84.0	86.5	86.5	85.5	87.5	87.5
5.0	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10.0	88.5	89.5	90.2	89.5	89.5	89.5
15.0	89.5	91.0	90.2	90.2	91.0	90.2
20.0	90.2	91.0	91.0	90.2	91.0	90.2
25.0	91.0	91.7	91.7	91.0	92.4	91.7
30.0	91.0	92.4	92.4	91.0	92.4	91.7
40.0	91.7	93.0	93.0	91.7	93.0	93.0
50.0	92.4	93.0	93.0	92.4	93.0	93.0
60.0	93.0	93.6	93.6	93.0	93.6	93.6
75.0	93.0	94.1	93.6	93.0	94.1	93.6
100.0	93.0	94.1	94.1	93.6	94.5	94.1
125.0	93.6	94.5	94.1	94.5	94.5	94.1
150.0	93.6	95.0	94.5	94.5	95.0	95.0
200.0	94.5	95.0	94.5	95.0	95.0	95.0

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 both supply and return ducts, whether heated or mechanically cooled. Mechanically cooled ducts requiring insulation shall have a vapor retarder, with a perm rating not greater than 0.5 and all joints sealed.

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

INSTALLED:

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

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

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

TABLE 14-6
Minimum Pipe Insulation (inches)[1]

Fluid Design Operating Temp. Range, °F	Insulation Conductivity		Nominal Pipe Diameter (in.)					
	Conductivity Range Btu • in./(h • ft² • °F)	Mean Rating Temp. °F	Runouts[2] up to 2	1 and less	>1 to 2	>2 to 4	>4 to 6	>6
Heating systems (Steam, Steam Condensate and Hot water)			Nominal Insulation Thickness					
Above 350	0.32-0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
251-350	0.29-0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
201-250	0.27-0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105-140	0.24-0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Domestic and Service Hot Water Systems								
105 and Greater	0.24-0.28	100	0.5	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine and Refrigerant)								
40-55	0.23-0.27	75	0.5	0.5	0.75	1.0	1.0	1.0
Below 40	0.23-0.27	75	1.0	1.0	1.5	1.5	1.5	1.5

1. Alternative Insulation Types. Insulation thicknesses in Table 14-6 are based on insulation with thermal conductivities within the range listed in Table 14-6 for each fluid operating temperature range, rated in accordance with ASTM C 335-84 at the mean temperature listed in the table. For insulation that has a conductivity outside the range shown in Table 14-6 for the applicable fluid operating temperature range at the mean rating temperature shown (when rounded to the nearest 0.01 Btu • in./(h • ft² • °F)), the minimum thickness shall be determined in accordance with the following equation:

$$T = PR[(1 + t/PR)^{K/k} - 1]$$

Where

T = Minimum insulation thickness for material with conductivity K, inches.
PR = Pipe actual outside radius, inches.
t = Insulation thickness from Table 14-6, inches.
K = Conductivity of alternate material at the mean rating temperature indicated in Table 14-6 for the applicable fluid temperature range, Btu • in/(h • ft² • °F).
k = The lower value of the conductivity range listed in Table 14-6 for the applicable fluid temperature range, Btu • in/(h • ft² • °F).

2. Runouts to individual terminal units not exceeding 12 ft. in length.

CHAPTER 15
LIGHTING AND MOTORS

1501 Scope: Interior and exterior lighting and electric motors shall comply with the requirements of this chapter.

SECTION 1510 -- GENERAL REQUIREMENTS: Lighting and motors shall comply with Sections 1511 through 1513. 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.

Figure 15A
Lighting and Motor 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
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	
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

1512.1 Exempt Spaces: The following rooms, spaces and areas, are exempt from the lighting power requirements in Sections 1520 and 1530 but shall comply with all other requirements of this chapter.

1. Areas in which medical or dental tasks are performed.
2. High risk security areas or any area identified by building officials as requiring additional lighting.
3. Spaces designed for primary use by the visually impaired, hard of hearing (lip-reading) or by senior citizens.
4. Food preparation areas.
5. Outdoor manufacturing, greenhouses and processing areas.
6. Electrical/mechanical equipment rooms.
7. Outdoor athletic facilities.
8. Inspection and restoration areas in galleries and museums.

1512.2 Exempt Lighting Equipment: The following lighting equipment and tasks are exempt from the lighting requirements of Section 1520 and need not be included when calculating the installed lighting power under Section 1530 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 integral to signs, and permanently ballasted lighting fixtures for walkways and pathways.

4. Lighting that is part of machines, equipment or furniture.

5. Lighting that is used solely for indoor plant growth during the hours of 10:00 p.m. to 6:00 a.m.

6. Lighting for theatrical productions, television broadcasting (including sports facilities), audio-visual presentations and special effects lighting for stage areas and dance floors in entertainment facilities.

7. Lighting for art exhibits, non-retail displays, portable plug in display fixtures and show case lighting.

8. Exterior lighting for public monuments.

1513 Lighting Controls

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 12, 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.

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: Exterior lighting not intended for 24-hour continuous use shall be automatically switched by timer, photocell or a combination of timer and photocell. 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.

1513.6 Automatic Shut-Off Controls, Interior: Office buildings greater than 25,000 ft^2.and all school classrooms shall be equipped with separate automatic controls to shut off the lighting during unoccupied hours. Automatic controls may be an occupancy sensor, time switch or other device capable of automatically shutting off lighting.

EXCEPTIONS: 1. Areas that must be continuously illuminated, or illuminated in a manner requiring manual operation of the lighting.

2. Emergency lighting systems.

3. Switching for industrial or manufacturing process facilities as may be required for production.

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.

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 footprint for footprints over 100,000 ft^2, whichever is greater.

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 are one- or two-lamp (but not three- or more lamp) non-lensed, fluorescent fixtures fitted with type T-5, T-6, T-8 or PL type lamps from 5 to 50 watts and electronic ballasts.

EXCEPTION: Up to a total of 5% of installed lighting fixtures need not be ballasted and may use any type of lamp.

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. Wattage for fluorescent lamps and ballasts shall be tested per ANSI Standard C82.2-1984.

The wattage used for any unballasted fixture shall be the maximum UL listed wattage for that fixture regardless of the lamp installed. The wattage used for track lighting shall be:

a. for line voltage track, 50 watts per lineal foot of track or actual luminare wattage, whichever is greater.

b. for low voltage track, 25 watts per lineal foot of track or the VA rating of the transformer, whichever is greater.

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.

If multiple uses are intended, the lighting power allowance for each type of 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 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: The exterior lighting power allowance shall be the sum of the calculated allowances for parking, outdoor areas and building exteriors. The lighting allowance for covered parking, open parking and outdoor areas shall be 0.20 W/ft^2. The lighting allowance for building exteriors shall be calculated either by multiplying the building facade area by 0.25 W/ft^2 or multiplying the building perimeter in feet by 7.5 watts per lineal foot.

Exception: Group M occupancy accessory to Group R occupancy.

TABLE 15-1
Unit Lighting Power Allowance (LPA)

Use[1]	LPA[2] (W/ft^2)
Painting, welding, carpentry, machine shops	2.30
Barber shops, beauty shops	2.00
Hotel banquet/conference/exhibition hall[3,4]	2.00
Laboratories	2.00
Aircraft repair hangars	1.50
Cafeterias, fast food establishments[5]	1.50
Factories, workshops, handling areas	1.50
Gas stations, auto repair shops[6]	1.50
Institutions	1.50
Libraries[5]	1.50
Nursing homes	1.50
Wholesale stores (pallet rack shelving)	1.50
Mall concourses	1.40
School buildings, school classrooms, day care centers	1.35
Laundries	1.30
Office buildings, office/administrative areas in facilities of other use types (including but not limited to schools, hospitals, institutions, museums, banks, churches)[5,7]	1.20
Police and fire stations[8]	1.20
Atria (atriums)	1.00
Assembly spaces[9], auditoriums, gymnasia[9], theaters	1.00
Process plants	1.00
Restaurants/bars[5]	1.00
Retail A[10]	1.00
Retail B[10], retail banking	1.50
Locker and/or shower facilities	0.80
Warehouses[11], storage areas	0.50
Aircraft storage hangars	0.40
Parking garages	See Section 1532
Plans Submitted for Common Areas Only[7]	
Common area, corridors, lobbies (except mall concourse)	0.80
Toilet facilities, washrooms	0.80

Footnotes for Table 15-1

1. 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. Includes pump area under canopy.

7. In cases in which a lighting plan is submitted for only a portion of a floor, a *Unit Lighting Power Allowance* of 1.35 may be used for usable office floor area and 0.80 W/ft^2 shall be used for the common areas, which may include elevator space, lobby area and rest rooms. Common areas, as herein defined do not include mall concourses.

8. For the fire engine room, the *Unit Lighting Power Allowance* is 1.00 W/ft^2.

9. For indoor sport tournament courts with adjacent spectator seating, the *Unit Lighting Power Allowance* for the court area is 2.60 W/ft^2.

10. For both *Retail A* and *Retail B,* light for free-standing display, building showcase illumination and display window illumination installed within 2 feet of the window are exempt.

    Retail A allows a *Unit Lighting Power Allowance* of 1.00 W/ft^2. Ceiling mounted adjustable tungsten halogen and HID merchandise display luminaires are exempt.

    Retail B allows a *Unit Lighting Power Allowance* of 1.5 W/ft^2, including all ceiling mounted merchandise display luminaires.

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.

CHAPTER 16
(RESERVED)

CHAPTER 17
STANDARDS

1701 Scope: The following standards shall apply to Chapters 11 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	Same as RS-27
RS-2 – RS-8	**(Reserved)**
RS-9	ASHRAE/IES Standard 90.1-1989, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings.
RS-10	Standard for Packaged Terminal Air Conditioners and Heat Pumps, ARI Standard 310/380-93.
RS-11 – RS-17	**(Reserved)**
RS-18	SMACNA, HVAC Duct Construction Standards Metal and Flexible, 2nd Edition, 1995.
RS-19 – RS-24	**(Reserved)**
RS-25	Thermal Bridges in Sheet Metal Construction from Appendix E of RS-9.
RS-26	Super Good Cents Technical Reference (Builder's Field Guide).
RS-27	1997 ASHRAE Fundamentals Handbook.
RS-28	**(Reserved)**
RS-29	Commercial 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, 1997 Edition.

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

ARI refers to the Air Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, 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
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

IES refers to the Illuminating Engineering Society, 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., 1300 Spring Street, Suite 500, Silver Spring, MD 20910
Phone (301) 589-NFRC Fax (301) 588-0854, Internet www.nfrc.org

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

CHAPTER 18
(RESERVED)

CHAPTER 19
(RESERVED)

CHAPTER 20
DEFAULT HEAT LOSS COEFFICIENTS

2001 General

2001.1 Scope: The following defaults will apply to Chapters 11 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.

2001.2 Description: These coefficients were developed primarily from data and procedures from Standard RS-27, and taken specifically from Standard RS-26, listed in Chapter 17.

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-26, listed in Chapter 17, are used, along with data from the sources referenced above.

2001.3 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
0.72	Interior horizontal surfaces, heat flow down
0.68	Interior vertical surfaces

2001.4 Compression of Insulation: Insulation which is compressed shall be rated in accordance with Table 20-A or reduction in value may be calculated in accordance with the procedures in Standard RS-27, listed in Chapter 17.

TABLE 20-A
R-Value of Fiberglass Batts Compressed within Various Depth Cavities

Insulation R-Value at Standard Thickness											
R-Value		**38**	**30**	**22**	**21**	**19**	**15**	**13**	**11**	**8**	**5**	**3**
Standard Thickness		**12"**	**9-1/2"**	**6-3/4"**	**5-1/2"**	**6-1/4"**	**3-1/2"**	**3-5/8"**	**3-1/2"**	**2-1/2"**	**1-1/2"**	**3/4"**
Nominal Lumber Sizes, Inches	Actual Depth of Cavity, Inches	Insulation R-Values when Installed in a Confined Cavity										
2 x 12	11-1/4	37	--	--	--	--	--	--	--	--	--	--
2 x 10	9-1/4	32	30	--	--	--	--	--	--	--	--	--
2 x 8	7-1/4	27	26	--	--	--	--	--	--	--	--	--
2 x 6	5-1/2	--	21	20	21	18	--	--	--	--	--	--
2 x 4	3-1/2	--	--	14	--	13	15	13	11	--	--	--
2 x 3	2-1/2	--	--	--	--	--	--	9.8	--	--	--	--
2 x 2	1-1/2	--	--	--	--	--	--	6.3	6.0	5.7	5.0	--
2 x 1	3/4	--	--	--	--	--	--	--	--	--	3.2	3.0

2002 Below Grade Walls And Slabs

2002.1 General: Table 20-1 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.

2002.2 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 20-1, 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 2 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.

2002.3 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 20-1
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

2003 On-Grade Slab Floors

2003.1 General: Table 20-2 lists heat loss coefficients for unheated and heated on-grade slab floors, in units of Btu/h • °F per lineal foot of perimeter.

2003.2 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.

2003.3 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.

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 20-2
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	--

2004 Floors Over Unconditioned Space

2004.1 General: Tables 20-3, 20-4 and 20-4a list heat loss coefficients for floors over unconditioned spaces in units of Btu/h • ft^2 • °F.

They are derived from procedures listed in standard RS-27, listed in Chapter 17, assuming an average outdoor temperature of 45°F, an average indoor temperature of 65°F, and a crawlspace area of 1350 ft^2 and 100 feet of perimeter. The crawlspace is assumed to be 2-1/2 feet high, with 24 inches below grade and 6 inches above grade.

2004.2 Category Description: Four configurations are considered: vented crawlspace, unvented crawlspace, heated plenum crawlspace and exposed floor.

Vented crawlspaces: Assumed to have 3.0 air changes per hour, with at least 1.0 ft^2 of net-free ventilation in the foundation for every 300 ft^2 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.

Unvented crawlspaces: Assumed to have 1.5 air changes per hour, with less than 1.0 ft^2 of net-free ventilation in the foundation for every 300 ft^2 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 of 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.

2004.3 Construction Description: Floors are assumed to be either joisted floors framed on 16 inch 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 20-3
Default U-Factors for Floors Over 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 20-4
Default U-factors for Floors Over Heated Plenum Crawlspace

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 20-4 reflect this higher rate of heat loss.

TABLE 20-4A
Exposed Floors

Nominal R-value	U-factor		
	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

2005 Above Grade Walls

2005.1 General: Tables 20-5, 20-5A and 20-5B 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-27, listed in Chapter 17.

2005.2 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 3 studs and each opening is framed using 2 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 2 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 2 studs or other means of fully insulating corners, and each opening is framed by 2 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 2 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

2005.3 Component Description: For wood stud frame walls, default coefficients for three types of walls are listed: single-stud walls, strap walls, and double-stud walls.

Single-Stud Wall: 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: 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: 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 2 walls. Stud spacing is assumed to be on 24 inch centers for both walls.

TABLE 20-5
DEFAULT U-FACTORS FOR ABOVE-GRADE WALLS

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

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

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

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

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

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

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

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

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

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

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

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

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

Metal Stud Walls: The nominal R-values in Table 20-5A 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 24 of Standard RS-27.

TABLE 20-5A
Default U-Factors and Effective R-Values for Metal Stud Walls and Default U-Factors for Metal Building

OVERALL ASSEMBLY U-FACTORS FOR METAL STUD WALLS

Nominal Wall Thickness, Inches	Nominal Insulation R-Value	Overall Assembly U-Factors	
		16" O.C.	24" O.C.
4	R-11	0.14	0.13
4	R-13	0.13	0.12
4	R-15	0.12	0.11
6	R-19	0.11	0.10
6	R-21	0.11	0.09
8	R-25	0.10	0.09

EFFECTIVE R-VALUES FOR METAL STUD AND INSULATED CAVITY ONLY

Cavity		Insulation		
Nominal Depth, Inches	Actual Depth, Inches	Nominal R-Value	Effective R-Value	
			16" O.C.	24" O.C.
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

DEFAULT METAL BUILDING U-FACTORS

	R-10	R-11	R-13	R-19	R-24	R-30
Faced fiber glass blanket insulation rolled over and perpendicular to structural frame. Metal covering sheets fastened to the frame, holding insulation in place.	0.133	0.127	0.114	0.091	na	na
Faced fiber glass batt insulation suspended between structural frame. Metal covering sheets fastened directly to frame.	0.131	0.123	0.107	0.079	0.065	0.057
Faced fiber glass blanket insulation rolled over and perpendicular to structural frame. Rigid insulation blocks placed over insulation to align with structural frame.	0.102	0.096	0.084	0.065	na	na
Faced fiber glass batt insulation suspended between structural frame. Rigid insulation blocks placed over insulation to align with structural frame.	0.099	0.093	0.080	0.059	0.048	0.041

Concrete Masonry Walls: The nominal R-values in Table 20-5B 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 24 of Standard RS-27.

TABLE 20-5B
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

	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 20-5B

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-27.

2006 Default U-Factors for Glazing and Doors

2006.1 Untested Glazing and Doors: Untested glazing and doors shall be assigned the following U-factors:

TABLE 20-6
Default U-Factors for Vertical Glazing, Overhead Glazing and Opaque Doors

Vertical Glazing

	U-Factor	
	Any Frame	Vinyl/Wood Frame
Single	1.45	1.45
Double	0.90	0.75
1/2 Inch Air, Fixed	0.75	0.60
1/2 Inch Air, Low-e$^{(0.40)}$, Fixed	0.60	0.50
1/2 Inch Argon, Low-e$^{(0.10)}$, Fixed	0.50	0.40

Overhead Glazing

	U-Factor	
	Any Frame	Vinyl/Wood Frame
Single	2.15	2.15
Double	1.45	1.00
Low-e$^{(0.40)}$ or Argon	1.40	0.95
Low-e$^{(0.40)}$ + Argon	1.30	0.85
Low-e$^{(0.20)}$ Air	1.30	0.90
Low-e$^{(0.20)}$ + Argon	1.25	0.80
Triple	1.25	0.80

Opaque Doors

	U-Factor
Uninsulated Metal	1.20
Insulated Metal (Including Fire Door and Smoke Vent)	0.60
Wood	0.50

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.

2007 Ceilings

2007.1 General: Table 20-7 lists heat loss coefficients for the opaque portion of exterior ceilings below vented attics, vaulted ceilings and roof decks in units of Btu/h • ft^2 • °F of ceiling.

They are derived from procedures listed in Standard RS-27, listed in Chapter 17. 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.

2007.2 Component Description: The three 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 • ft^2 • °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 3.0 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:

U-Factor for Standard Framing

Roof Pitch	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.

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 20-7A, 20-7B, 20-7C, 20-7D and 20-7E.

TABLE 20-7
Default U-factors for Ceilings

Ceilings Below Vented Attics	Standard Frame	Advanced Frame
Flat Ceiling	**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	U-factor
R-15 Rigid Insulation	0.063
R-21 Rigid Insulation	0.045
R-25 Rigid Insulation	0.038
R-30 Rigid Insulation	0.032
R-38 Rigid Insulation	0.025
R-50 Rigid Insulation	0.019

Table 20-7A
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 20-7B
Steel Truss[1] Framed Ceiling U_o with R-3 Sheathing[2]

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 20-7C
Steel Truss[1] Framed Ceiling U_o with R-5 Sheathing[2]

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 20-7D
Steel Truss[1] Framed Ceiling U_o with R-10 Sheathing[2]

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 20-7E
Steel Truss[1] Framed Ceiling U_o with R-15 Sheathing[2]

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.

2008 (Reserved)

2009 Mass

2009.1 General: Table 20-10 lists default mass values for concrete masonry construction. Calculations are based on standard ASHRAE values for heat-storage capacity as listed in Standard RS-27, Chapter 24.

TABLE 20-10
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

APPENDIX

REFERENCE STANDARD 29
(RS-29)

COMMERCIAL BUILDING DESIGN
BY SYSTEMS ANALYSIS

REFERENCE STANDARD
COMMERCIAL BUILDING DESIGN BY SYSTEMS ANALYSIS

Section 1 – Scope

1.1 General: This Standard establishes design criteria in terms of total energy consumption of a building, including all of its systems. General principles and requirements are outlined in Section 2. Specific modeling assumptions are listed in Section 3.

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 design for the project corresponds with tbe annual energy analysis. If credit is proposed to be taken for lighting energy savings, then electrical drawings shall also be included with the building permit application.

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

Section 2 – General Principles and Requirements

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

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

a. The calculated annual energy consumption is not greater than that of a corresponding "standard design," as defined below and in Section 3; and,

b. Whose enclosure elements and energy-consuming systems comply with Sections 1310 through 1314, 1410 through 1415,1440 through 1442, 1450 through 1454, and 1510 through 1513. Buildings shall only vary from those requirements in Sections 1330 through 1334, 1432 through 1438, and 1530 through 1532 where those variations have been accurately and completely modeled. Where variations are not specifically analyzed, the building shall comply with these requirements.

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

Except as noted below, the systems identified, and, to the extent possible, the assumptions made in assigning energy inputs to each system, shall be the same for the standard design and the proposed design. When electrically driven heat pumps, other than multiple units connected to a common water loop, are employed to provide all or part of the heat for the proposed design, the standard design shall also, for the purposes of the analysis, assume that electrically driven heat pump, in conformance with Chapter 14 of the Code and having capacity at least as great as those used in the proposed design are employed.

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

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

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

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

a. The building heating/cooling load calculation procedure used for annual energy consumption analysis shall be detailed to permit the evaluation of effect of factors specified in Section 2.4.

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 and shall utilize the design methods, specified in Standards RS-27, -11, -12, and -13 listed in Chapters 7 and 17 of the Code or in other programs approved by the building official.

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

a. Design requirements–Design heating conditions and design cooling conditions as defined in Chapter 12 of the Code.

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

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

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

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

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

EXCEPTION: Proposed designs having an area of 25,000 square feet or less are exempt from the full-year energy analysis described in Section 2.3(b). However, comparison of energy consumption between the proposed design and the standard design shall be provided based on one of the programs suggested in Section 4.2 for these buildings.

2.5 Documentation: All analyses submitted 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 Section 1.

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

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

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

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

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

SECTION 3 — SPECIFIC MODELING ASSUMPTIONS

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

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

3.1 Orientation and Shape: The standard building shall consist of the same number of stories and gross floor area for each story as the proposed design. Each floor shall be oriented exactly as the proposed design. The geometric form shall be the same as the proposed design.

3.2 Internal Loads: Internal loads shall be modeled as noted in the following parts of Section 3.2. The systems specified for calculating the standard energy consumption in Section 3.2 are intended only as constraints in calculating the consumption. They are not intended as requirements or recommendations for systems to be used in the proposed building or for the calculation of the proposed energy consumption.

3.2.1 Occupancy: Occupancy schedules shall be default assumptions. The same assumptions shall be made in computing proposed energy consumption as were used in calculating the standard energy consumption. Occupancy levels vary by building type and time of day. Table 3-1 establishes the density presented as ft^2/person of conditioned floor area that will be used by each building type. Table 3-2 establishes the percentage of the people that are in the building by hours of the day for each building type.

3.2.2 Lighting: The interior and exterior lighting power allowance for calculating the standard energy consumption shall be determined from Sections 1531 and 1532. The lighting power used to calculate the proposed energy consumption shall be the actual lighting power of the proposed lighting design. Exempt lighting in the standard design shall be equal to the exempt lighting in the proposed design.

Lighting levels in buildings vary based on the type of uses within buildings, by area and by time of day. Table 3-2 contains the lighting energy profiles which establish the percentage of the lighting load that is switched ON in each prototype or reference building by hour of the day. These profiles are default assumptions and can be changed if required when calculating the standard energy consumption to provide, for example, a 12-hour rather than an 8-hour work day or to reflect the use of automatic lighting controls. The lighting schedules used in the standard and proposed designs shall be identical and shall reflect the type of controls to be installed in the proposed design. The controls in the proposed design shall comply with the requirements in Section 1513 and no credit shall be given for the use of any additional controls, automatic or otherwise.

3.2.3 Receptacle: Receptacle loads and profiles are default assumptions. The same assumptions shall be made in calculating proposed energy consumption as were used in calculating the standard energy consumption. Receptacle loads include all general service loads that are typical in a building. These loads should include additional process electrical usage but exclude HVAC primary or auxiliary electrical usage. Table 3-1 establishes the density in W/ft^2 to be used. The receptacle energy profiles shall be the same as the lighting energy profiles in Table 3-2. This profile establishes the percentage of the receptacle load that is switched ON by hour of the day and by building type.

3.3 Envelope

3.3.1 Insulation and Glazing: Glazing area and U-factor of the standard building envelope shall be determined by using the Target UA requirements of Equation 13-1 and U-factor values in Table 13-1 or 13-2. The glazing solar heat gain coefficient (SHGC) or shading coefficient of the standard building shall be the lesser of 0.65 and the SHGC required by Table 13-1 or 13-2 for the vertical or overhead glazing area for the appropriate wall type. The opaque area U-factors of the standard building shall be determined by using the Target UA requirements from Equation 13-1 including the appropriate mass for walls. The insulation characteristics and glazing area are prescribed assumptions for the standard building for calculating the standard energy consumption. In the calculation of the proposed energy consumption of the proposed design, the envelope characteristics of the proposed design shall be used. The standard design shall use the maximum glazing areas listed in Tables 13-1 or 13-2 for the appropriate use. The distribution of vertical glazing in the gross wall area of the standard design shall be equal to the distribution of vertical glazing in the proposed design or shall constitute an equal percentage of gross wall area on all sides of the standard building. The distribution of overhead glazing in the gross roof/ceiling area of the standard design shall be equal to the distribution of overhead glazing in the proposed design. The distribution of doors in the gross opaque wall area of the standard design shall be identical to the distribution of doors in the proposed design.

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

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

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

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

3.4 HVAC Systems and Equipment: For the standard building, the HVAC system used shall be the system type used in the proposed design. If the proposed HVAC system type does not comply with Sections 1432 through 1438, the standard design system shall comply in all respects with those sections.

> **EXCEPTION:** When approved by the building official, a prototype HVAC system may be used, if the proposed design system cannot be modified to comply with Sections 1422 and 1432 through 1438, as a standard design. Use of prototype HVAC systems shall only be permitted for the building types listed below. For mixed-use buildings, the floor space of each building type is allocated within the floor space of the standard building. The specifications and requirements for the HVAC systems of prototype buildings shall be those in Table 3-3.
>
> 1. assembly
> 2. health/institutional
> 3. hotel/motel
> 4. light manufacturing
> 5. office (business)
> 6. restaurant
> 7. retail (mercantile)
> 8. school (educational)
> 9. warehouse (storage)

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

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

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

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

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

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

3.4.4 Variable Speed: The energy of the combined fan system per air volume at design conditions (w/cfm) of the proposed design shall be equal to that of the standard design.

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

3.5 Service Water Heating: The service water heating loads for prototype buildings are defined in terms of Btu/person-hour in Table 3-1. The values in the table refer to energy content of the heated water. The service water heating loads from Table 3-1 are default for all buildings. The same service-water-heating load assumptions shall be made in calculating proposed energy consumption as were used in calculating the standard energy consumption. The service water heating system for the standard building shall be modeled as closely as possible as if it were designed in accordance with the ASHRAE Handbook, 1995 HVAC Applications Volume, and meeting all the requirements of Sections 1440 through 1442.

3.6 Controls

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

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

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

3.6.2: Space temperature controls for the standard building shall be set at 70 °F for space heating and 75 °F for space cooling, with a deadband in accordance with Section 1412.2. The system shall be OFF during off-hours according to the appropriate schedule in Table 3-2, except that the heating system shall cycle ON if any space should drop below the night setback setting 55 °F. There shall be no similar setpoint during the cooling season. Lesser deadband ranges may be used in calculating the proposed energy consumption.

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

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

3.6.3: When providing for outdoor air ventilation when calculating the standard energy consumption, controls shall be assumed to close the outside air intake to reduce the flow of outside air to 0.0 cfm during "setback" and "unoccupied" periods. Ventilation using inside air may still be required to maintain scheduled setback temperature. Outside air ventilation, during occupied periods, shall be as required by the Washington State Ventilation and Indoor Air Quality Code, Chapter 51-13 WAC.

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

TABLE 3-1

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

Building Type	Occupancy Density[2] Sq.Ft./Person (Btu/h · ft²)	Receptacle Power Density[3] Watts/Sq.Ft. (Btu/h · ft²)	Service Hot Water Quantities[4] Btu/h · Person
Assembly	50 (4.60)	0.25 (0.85)	215
Health/Instutional	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 (.034)	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 3-2A
Assembly Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2B
Health Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2C
Hotel/Motel Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2D
Light Manufacturing Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2E
Office Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2F
Parking Garage Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2G
Restaurant Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2H
Retail Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2I
School Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-2J
Warehouse Occupancy[1]

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

Wk = Weekday

1. Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 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 3-3
HVAC Systems of Prototype Buldings[3]

Use	System #	Remarks
1. Assembly		
a. Churches (any size)	1	
b. ≤ 50,000 ft² or ≤ 3 floors	1 or 3	Note 2
c. > 50,000 ft² or > 3 floors	3	
2. Health		
a. Nursing Home (any size)	2	
b. ≤ 15,000 ft²	1	
c. > 15,000 ft² and ≤ 50,000 ft²	4	Note 3
d. > 50,000 ft²	5	Note 3,4
3. Hotel/Motel		
a. ≤ 3 Stories	2	Note 6
b. > 3 Stories	6	Note 7
4. Light Manufacturing	1 or 3	
5. Office		
a. ≤ 20,000 ft²	1	
b. > 20,000 ft² and either ≤ 3 floors or ≤ 75,000 ft²	4	
c. > 75,000 ft² or > 3 floors	5	
6. Restaurant	1 or 3	Note 2
7. Retail		
a. ≤ 50,000 ft²	1 or 3	Note 2
b. > 50,000 ft²	4 or 5	Note 2
8. Schools		
a. ≤ 75,000 ft² or ≤ 3 floors	1	
b. > 75,000 ft² or > 3 floors	3	
9. Warehouse		Note 5

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

TABLE 3-3 (Continued)
HVAC System Descriptions for Prototype Buildings[1]

HVAC Component	System #1	System #2
System Description	Packaged rooftop single zone, one unit per zone	Packaged terminal air conditioner with space heater or heat pump, heating or cooling unit per zone
Fan system Design Supply Circulation Rate	Note 10	Note 11
Supply Fan Control	Constant volume	Fan cycles with call for heating or cooling
Return Fan Control	NA	NA
Cooling System	Direct expansion air cooled	Direct expansion air cooled
Heating System	Furnace, heat pump or electric resistance	Heat pump with electric resistance auxiliary or air conditioner with space heater
Remarks	Drybulb economizer per Section 1433, heat recovery if required by Section 1436	No economizer, if not required by Section 1433

TABLE 3-3 (Continued)
HVAC System Descriptions for Prototype Buildings[1]

HVAC Component	System #3	System #4
System Description	Air handler per zone with central plant	Packaged rooftop VAV with perimeter reheat and fan-powered terminal units
Fan system Design Supply Circulation Rate	Note 10	Note 10
Supply Fan Control	Constant volume	VAV with forward curved centrifugal fan and variable inlet fans
Return Fan Control	Constant volume	VAV with forward curved centrifugal fan and discharge dampers
Cooling System	Chilled water (Note 12)	Direct expansion air cooled.
Heating System	Hot water (Note 13)	Hot water (Note 13) or electric resistance
Remarks	Drybulb economizer per Section 1433, heat recovery if required by Section 1436.	Drybulb economizer per Section 1433. Minimum VAV setting per Section 1435 Exception 1; Supply air reset by zone of greatest cooling demand, heat recovery if required by Section 1436

TABLE 3-3 (Continued)
HVAC System Descriptions for Prototype Buildings[1]

HVAC Component	System #5	System #6
System Description	Built-up central VAV with perimeter reheat and fan-powered terminal units	Four-pipe fan coil per zone with central plant
Fan system Design Supply Circulation Rate	Note 10	Note 10
Supply Fan Control	VAV with air-foil centrifugal fan and AC frequency variable speed drive	Fan cycles with call for heating or cooling
Return Fan Control	VAV with air-foil centrifugal fan and AC frequency variable speed drive	NA
Cooling System	Chilled water (Note 12)	Chilled water (Note 12)
Heating System	Hot water (Note 13) or electric resistance	Hot water (Note 13) or electric resistance
Remarks	Drybulb economizer per Section 1433. Minimum VAV setting per Section 1435 Exception 1; Supply air reset by zone of greatest cooling demand, heat recovery if required by Section 1436	No economizer, if not required by Section 1433

Numbered Footnotes for Table 3-3
HVAC System Descriptions for Prototype Buildings

1. The systems and energy types presented in this Table are not intended as requirements or recommendations for the proposed design.
2. For occupancies such as restaurants, assembly, and retail that are part of a mixed use building which, according to Table 3-3, includes a central chilled water plant (systems 3, 5, or 6), chilled water system type 3 or 5 shall be used as indicated in the Table.
3. Constant volume may be used in zones where pressurization relationships must be maintained by code. Where constant volume is used, the system shall have heat recovery if required by Section 1436. VAV shall be used in all other areas, in accordance with Sections 1432 through 1438.
4. Provide run-around heat recovery systems for all fan systems with a minimum outside air intake greater than 70%. Recovery effectiveness shall be 0.50.
5. If a warehouse is not intended to be mechanically cooled, both the standard and proposed designs shall be calculated assuming no mechanical cooling.
6. The system listed is for guest rooms only. Areas such as public areas and back-of-house areas shall be served by system 4. Other areas such as offices and retail shall be served by systems listed in Table 3-3 for these occupancy types.
7. The system listed is for guest rooms only. Areas such as public areas and back-of- house areas shall be served by system 5. Other areas such as offices and retail shall be served by systems listed in Table 3-3 for these occupancy types.
8. Reserved.
9. Reserved.
10. Design supply air circulation rate shall be based on a supply-air to room-air temperature difference of 20°F. A higher supply air temperature may be used if required to maintain a minimum circulation rate of 4.5 air changes per hour or 15 cfm per person to each zone served by the system, at design conditions. If return fans are specified, they shall be sized for the supply fan capacity less the required minimum ventilation with outside air, or 75% of the supply fan capacity, whichever is larger. Except where noted, supply and return fans shall be operated continuously during occupied hours.
11. Fan energy when included in the efficiency rating of the unit as defined in Section 1411, need not be modeled explicitly for this system. The fan shall cycle with calls for heating or cooling.
12. Chilled water systems shall be modeled using a reciprocating chiller for systems with total cooling capacities less than 175 tons, and centrifugal chillers for systems with cooling capacities of 175 tons or greater. For systems with cooling capacities of 600 tons or more, the standard design energy consumption shall be calculated using two centrifugal chillers, lead/lag controlled. Chilled water shall be assumed to be controlled at a constant 44°F. Chiller water pumps shall be sized using a 12°F temperature rise, from 44°F to 56°F, operating at 65% combined impeller and motor efficiency. Condenser water pumps shall be sized using a 10°F temperature rise, operating at 60% combined impeller and motor efficiency. The cooling tower shall be an open circuit, centrifugal blower type sized for the larger of 85°F leaving water temperature or 10°F approach to design wetbulb temperature. The tower shall be controlled to provide a 65°F leaving water temperature whenever weather conditions permit, floating up to design leaving water temperatures at design conditions. Chilled water supply temperature shall be reset in accordance with Section 1432.2.2.
13. Hot water system shall include a natural draft fossil fuel or electric boiler. The hot water pump shall be sized based on a 30°F temperature drop, from 180°F to 150°F, operating at a combined impeller and motor efficiency of 60%. Hot water supply temperature shall be reset in accordance with Section 1432.2.2.

SECTION 4 – SUGGESTED SOFTWARE FOR SYSTEMS ANALYSIS APPROACH

4.1 Programs Acceptable for Projects for Full-Year Hourly Analysis

ADM-DOE
ADM Associates
3239 Ramos Circle
Sacramento, CA 95827
916-363-8383

Blast 3.0 (Level 193)
Blast Support Office
University of Illinois
Dept. of Mechanical and Industrial Engineering
1206 W. Green Room 30, MEB
Urbana, IL 61801
1-800-842-5278

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

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. 4th Centre, Suite 2100
Dayton, OH 45402
937-228-2602

HAP 2.02
Carrier Building Systems and Services
3215 S 116th Street, Suite 133
Tukwilla, WA 98168
206-439-0097

MICRO-DOE2
ACROSOFT CAER Engineers
1204-1/2 Washington Avenue
Golden, CO 80401
303-279-8136

Trace 600 Version 16.08
The Trane Co.
3600 Pammel Creek Rd.
Lacrosse, WI 54601
608-787-3926

4.2 Programs only Acceptable for Commercial Buildings 25,000 Square Feet or Less

ADM.2
ADM Associates
3239 Ramos Circle
Sacramento, CA 95827
916-363-8383

ASEAM
U.S. Dept. of Energy Clearinghouse
800-DOE-EREC (800-363-3732)

Building Energy Analysis and Easy DOE
Elite Software
PO Drawer 1194
Bryan, TX 77806
409-846-2340

ESE
Sea Gate
5100 W 82nd Streer, Suite 204
Bloomington, MN 55437
612-844-8000

Market Manager
SRC Systems
2855 Telegraph Avenue, Suite 410
Berkley, CA 94705
510-848-8400

XENCAP 4.5
XENERGY
492 9th Street, Suite 220
Oakland, CA 94607
510-891-0446