WASHINGTON STATE ENERGY CODE

(1991 Second Edition)
Chapter 51-11 WAC

Washington State Building Code Council
Effective July, 1992

Washington state energy code (1991 second edition) Chapter 51-11 WAC

PREFACE

Authority: The Washington State Building Code Council adopted the 1991 Washington State Energy Code pursuant to RCW 19.27A.020. This code provides 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.

Code Precedence: The 1991 Washington State Energy Code supersedes Chapter 51-12 WAC as published in the Washington State Administrative Code.

Organization and Numbering: This code, by design, is a stand-alone code, and follows the model Energy Code format.

Effective Date: These regulations shall be effective July 1, 1992.

Copies and Comments: The Department of Community Development provides staff and administrative services to the Council. Copies of WAC 51-11 and information on amendments to codes adopted by the State Building Code Council may be obtained from:

Department of Community Development
Washington State Building Code Council
906 Columbia Street SW
P.O. Box 48300
Olympia, Washington 98504-8300
(206) 586-2251

Second Edition Titled
1991 Washington State Energy Code
1991 Second Edition
Effective July 1, 1992
Printed June 1992

Second edition based on:
WSR 92-01-140

1991 WASHINGTON STATE ENERGY CODE
SECOND EDITION
TABLE OF CONTENTS

CHAPTER 1
ADMINISTRATION AND ENFORCEMENT

SECTION 101 -- SCOPE AND GENERAL REQUIREMENTS

101.1 Title: This Code shall be known as the "Washington State 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 benefitted 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 public assembly, educational, business, mercantile, institutional, storage and residential occupancies, as well as those portions of factory and industrial occupancies designed primarily for human occupancy 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.

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 sections 602 and 605, but shall comply with all other requirements for building mechanical systems, service water heating and lighting systems.

101.3.1.1: Buildings and structures or portions thereof whose peak design rate of energy usage is less than three and four tenths (3.4) Btu/h per square foot or one point zero (1.0) watt per square foot 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 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:

1. Any Other than Group R Occupancy which is presently unconditioned where the occupancy or use is changed to require conditioning shall be required to be brought into full compliance with this Code.
2. The use or occupancy of any Other than Group R Occupancies which are presently conditioned may be changed without complying with this Code, provided additional heat or cooling is not added.
3. Any Other than Group R Occupancy which is converted to Group R Occupancy shall be brought into full compliance with this Code.
4. Any Group R Occupancy which is converted to Other than Group R Occupancy shall be required to comply with all of the provisions of this Code if either new or increased heating or cooling is provided.
5. All Occupancies, which are converted from a Group R Occupancy or an Other than Group R Occupancy or use, to a new Other than Group R Occupancy or use shall comply with the lighting standards set forth in this Code unless the existing lighting is not altered.

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 or 5-2 of Chapter 5, or the nominal R-values and glazing requirements of the reference case in Tables 6-1 to 6-6 or 6-7.

Exceptions:

1. Untested storm windows may be installed over existing glazing for an assumed U-value of 0.90, however, where glass and sash are being replaced in Group R Occupancy, glazing with a maximum area weighted average U-value of 0.40 shall be installed where there is an electric resistance space heating system and glazing with a maximum U-value of 0.65 (Climate Zone I) and 0.60 (Climate Zone II) shall be installed where there is any other space heating system.

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 non-existent.

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.

101.3.2.8 Lighting: Those parts of systems which are altered or replaced in buildings initially constructed subject to the requirements of this Code shall comply with section 505. Other remodels or replacements of lighting systems which are part of a substantial remodel shall comply with section 505. In addition, remodeling of any size area with or without putting a new ceiling grid or suspension system when reusing existing fixtures and/or adding new ones shall not require compliance with the lighting power budget as long as the installed wattage is maintained or reduced. Remodeling of an entire floor or an entire tenant space that includes a new lighting system with or without a new ceiling grid or suspension system shall require compliance of a lighting power budget of section 505. Compliance with switching requirements of section 505.2 is only required when new wiring is being run related to adding fixtures and/or fixtures are being relocated to a new circuit.

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 ten percent 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 Occupancy in each town, city and county, no later than July 1, 1991. This Code shall be the minimum energy Code for all other than Group R Occupancies in each town, city and county.

SECTION 102 -- MATERIALS AND EQUIPMENT

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

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

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

The provisions of this Code are not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been approved by the building official as meeting the intent of this Code. The building official may approve any such alternate provided he finds the proposed alternate meets or exceeds the provisions of this Code and that the material, method, design or work offered is for the purpose intended, at least the equivalent of that prescribed in this Code, in quality, strength, effectiveness, fire-resistance, durability, safety, and efficient use and conservation of energy. The building official may require that sufficient evidence of proof be submitted to substantiate any claims that may be made regarding performance capabilities.

SECTION 104 -- PLANS AND SPECIFICATIONS

104.1 General: If required by the building official, plans and specifications shall be submitted in support of an application for a building permit. If required by the building official, plans and specifications shall be stamped and authenticated by a registered design professional currently licensed in the state of Washington. If required by the building official, all energy calculations submitted under the provisions of Chapter 4 for other than Group R Occupancy shall be stamped and authenticated by an engineer or architect licensed to practice by the state. 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-values 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 305(e) 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 and (Chapter 51-16 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 section 1005 of the Uniform Mechanical Code, 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.

AAMA: American Architectural Manufacturers Association.

ACCEPTED ANALYSIS METHODS: Heating/cooling and lighting load calculations performed in accordance with the most current procedures developed by a nationally recognized professional organization and approved by the building official.

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.**)

ADVANCED FRAMED WALLS: Studs framed on twenty-four 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.

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

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.**)

BASEMENT WALL: The opaque portion of a wall which encloses a basement and is partially or totally below grade.

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.

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.

CLERESTORY: A window placed in a wall projecting from a roof plane at sixty degrees or more from the horizontal to admit daylight into the interior of a building. (See **Skylight.**)

COMFORT ENVELOPE: The area on a psychometric 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).

CONTINUOUS AIR BARRIER: A system of materials installed during construction that is designed to effectively minimize the transfer of air to or from the conditioned space though unintentional openings in the building envelope.

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 under designated rating conditions.(See **Net Heat Output, Net Heat Removal, Total On-Site Energy Input.**)

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

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

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 fifty percent of the door area, the glazing area is the daylight opening area. For all other doors, the glazing area is the door area.

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

GROSS EXTERIOR WALL AREA: The normal projection of the building envelope wall area bounding interior space which is conditioned by an energy-using system; 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 (in Btu) of a heat pump during its normal annual usage period for heating divided by the total (watt hour) electric power input 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, IOCFR. 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**.)

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.

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 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 eighty-five °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 distributions systems which are capable of maintaining air temperature within the space of fifty °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 exterior ambient conditions to and encloses a conditioned space. The gross area of a roof/ceiling assembly consists of the total interior surface of such assembly, including skylights.

ROOM AIR CONDITIONER: A packaged assembly designed as a unit primarily for mounting in a window or through a wall, or as a console, and designed to provide free delivery of conditioned air to an enclosed space, room or zone. It includes a prime source of refrigeration for cooling and dehumidification and means for circulating and cleaning air, and may also include means for ventilating and heating.

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.

SERVICE WATER HEATING DEMAND: The maximum design rate of energy withdrawal from a service water heating system in a designated period of time (usually an hour or a day).

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 sixty degrees 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 twenty-four 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 twenty-four 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.

STANDARD FRAMING: All framing practices not defined as "intermediate" or "advanced" shall be considered standard.
(See **Advanced framed ceiling, Advanced framed walls, Intermediate framed wall.**)

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.

SUBSTANTIALLY REMODELED OR REHABILITATED: Any alteration or restoration of a building or structure within any twelve month period, the cost of which exceeds sixty percent of the current replacement value of the particular building or structure.

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.

TERMINAL ELEMENT: The means by which the transformed energy from a system is finally delivered; i.e., registers, diffusers, lighting fixtures, faucets, and similar elements.

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 ($Btu/hr \bullet ft^2 \bullet {}^\circ F$).

THERMAL RESISTANCE (R): The reciprocal of thermal conductance ($hr \bullet ft^2 \bullet {}^\circ F/Btu$).

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 ($Btu/hr \bullet ft_2 \bullet {}^\circ F$). The U-value applies to the fractional combinations of different materials used in series along the heat flow path.

THERMAL TRANSMITTANCE, OVERALL (U_o): The overall (average) heat transmission of a gross area of the exterior building envelope ($Btu/hr \bullet ft^2 \bullet {}^\circ F$). The U_o-value 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 devices, 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-VALUE: (See **Thermal Transmittance.**)

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 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 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 sixty degrees 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.

WATER-CHILLING PACKAGE OF ABSORPTION: A factory-designed and prefabricated assembly (not necessarily shipped as a single package) of one or more condensers, evaporators (water coolers), absorbers and generators with interconnections and accessories used for chilling water.

WATER-CHILLING PACKAGE, CENTRIFUGAL OR ROTARY: A factory-designed and prefabricated assembly (not necessarily shipped as one package) or one or more centrifugal or rotary compressors, condensers and water coolers (evaporators) with interconnections and accessories used for chilling water.

WATER-CHILLING PACKAGE, RECIPROCATING: A factory-designed and prefabricated assembly, self-contained or condenserless, of one or more reciprocating compressors, condenser (self-contained only), water coolers (evaporator) and interconnections and accessories used for chilling water. The condenser may be air, evaporatively or water cooled.

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 percent column for winter and 0.5 percent 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 thirty percent. 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 Occupancy shall comply with section 402.1 to 402.6. Analysis of design for other buildings shall comply with sections 402.2 to 402.6.

SECTION 402 -- SYSTEMS ANALYSIS

402.1 Special Requirements for All Group R Occupancy

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:

	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/hr
R-1 units	1500 Btu/hr

PARAMETER	VALUE
Domestic Hot Water Heater Setpoint	120°F
Domestic Hot Water Consumption	20 gallons/person/day.
Minimum Heat Storage	Calculated using standard engineering practice for the actual building or as approved.
Site Weather Data	Typical meteorological year (TMY) or ersatz TMY data for the closest appropriate TMY site or other sites as approved.
Heating 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 shading coefficients.
4. Heating system efficiency;

402.1.4 Solar Shading and Access: Building designs using passive solar features with eight percent 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 forty-five 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 pumps 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 eight thousand seven hundred and sixty 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-value 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-value 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-values specified in this section.

The U-values 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 19-27 in RS-1 listed in Chapter 7, using the framing factors listed in Chapter 10 where applicable.

For envelope assemblies containing metal framing, the U-value 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 22 of RS-1, listed in Chapter 7.
4. Effective framing/cavity R-values as provided from the following table for metal stud walls:

WALL FRAMING	CAVITY INSULATION	
	R-11	R-19
2 x 4 @ 16" o.c.	5.50	-
2 x 4 @ 24" o.c.	6.60	-
2 x 6 @ 16" o.c.	-	7.60
2 x 6 @ 24" o.c.	-	8.55

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 1712 and/or 1713 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. To the maximum extent possible, insulation shall extend over the full component area to the intended R-value.

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 twenty-five and a smoke density not to exceed four hundred fifty when tested in accordance with UBC Standard 42-1.

Exceptions:

1. Foam plastic insulation shall comply with section 1712 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 1713 of the Uniform Building Code.

502.1.4.3 Clearances: Where required, insulation shall be installed with clearances according to manufacturers 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 three feet in twelve and there is at least thirty 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 3205(c) 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 six inches vertically above the height of noncompressed insulation, and twelve 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 twenty-four 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 1008 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 thirty degrees 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 twenty-four inches or downward and then horizontally beneath the slab for a minimum combined distance of twenty-four inches. Insulation installed outside the foundation shall extend downward to a minimum of twenty-four 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:

a. 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.
b. 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-Values: For Group R Occupancy, glazing and door U-values shall be determined in accordance with section 502.1.5.1. For other occupancies, glazing and door U-values shall be determined in accordance with either section 502.1.5.1 or 502.1.5.2.

502.1.5.1 Standard Procedure for Determination of Glazing and Door U-Values: U-values for glazing and doors, including all fire doors, shall be the tested U-values for thermal transmittance due to conduction resulting from either the AAMA 1503.1-88 test procedure or the ASTM C236-87 or C976-82 test procedures, provided that testing shall be conducted under established winter horizontal heat flow test conditions using fifteen mile per hour wind speed directed perpendicular to the exterior surface of the glazing as specified under AAMA 1503.1-88.

AAMA 1503.1-88 testing, shall be conducted by a laboratory accredited by AAMA to perform that test. ASTM C236-87 or C976-82 testing shall be conducted by an independent laboratory accredited by a nationally recognized accreditation program, independent of that laboratory. All tested U-values reported for listing by the State Building Code Council after January 1, 1991, shall include certification by the manufacturer of gas content in the sealed insulated glass unit used for testing and in the production unit.

Product samples tested shall be production line units or representative of units as purchased by the consumer or contractor. Product sample sizes tested shall be in accordance with AAMA 1503.1-88, except that skylights shall be tested with a nominal two foot by four foot size, or a nominal four foot by four foot size. The installation of the test sample shall be in accordance with AAMA 1503.1-88, section 8.4. All testing performed after January 1, 1991 shall not include screens. All glazing and doors shall be identified with a label that states an overall product U-value that is no less than the actual tested U-value. The labeled U-value 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 level A.

Exceptions:

1. The exterior frame dimensions of the product sample size tested shall not deviate by more than three inches from the height and width specified, except that skylights are allowed to be tested in the closest production line size to that specified above.
2. Passive air inlets are not required to be part of the tested assembly.
3. Products tested prior to December 31, 1990, to AAMA 1503.1-80, ASTM C236-80 or C976-82 which are not in compliance with the test size requirement above, and which are in compliance with the product sample sizes in AAMA 1503.1-80, shall be acceptable until December 31, 1994.
4. Untested glazing and doors shall be assigned the default U-values listed in Chapter 10. The default values for the opaque portions of doors shall be those listed in Chapter 10, provided that the U-value listed for a door with a thermal break shall only be allowed if both the door and the frame have a thermal break.
5. The U-value of an insulated glazing product which has a 'grille pattern' installed between the glazing layers shall be deemed equal to the U-value of an insulated glazing product which is tested without a 'grille pattern' in between glazing layers, provided a minimum 1/8 inch air space exists between the 'grille pattern' and both glass lites.
6. For a glazing product which is manufactured with an alternative 'low-e coating' than the 'low-e coating' of the tested glazing product, the U-value shall be deemed equal provided that the alternative 'low-e coating' material has an equal or lower rated emissivity.
7. U-Factors, either tested or simulated, labeled and certified in accordance with the National Fenestration Rating Council's (NFRC) procedure 100-91 are acceptable if based on model size AA.

502.1.5.2 Alternate Glazing and Door U-Values for Other Than Group R Occupancy: Glazing U-values for other than Group R Occupancy are also allowed to be taken from Table 13 of Chapter 27 of RS-1 listed in Chapter 7 or calculated in accordance with the procedures of Chapter 27 of RS-1 listed in Chapter 7 and door U-values are also allowed to be taken from Table 6 in Chapter 22 of RS-1 listed in Chapter 7.

502.1.6 Moisture Control

502.1.6.1: 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. polyethylene or kraft faced material).

502.1.6.3: Roof/Ceiling assemblies where the ventilation space above the insulation is less than an average of twelve 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 twelve 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 Wall Insulation: 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 twelve 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 three and one-half inches.

502.2 Thermal Criteria for Group R Occupancy

502.2.1: 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 figures in Table 5-1, and all the glazing shall be located in the wall area. The opaque door area shall be the same in the target UA and the proposed UA.

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 per dwelling unit, or; 2) One watt per square foot 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 EXCEPTIONS, Electric Resistance, section 502.2.2 above.)

502.3 Thermal Performance Criteria for Other Than Group R Occupancies

502.3.1: The overall thermal transmittance value (U_o) of the gross area of elements of the exterior building envelope of all Other Than Group R Occupancies shall not exceed the values given in Table 5-2. Equations 2, 4 and 5 shall be used to determine acceptable combinations of building components and thermal properties to meet this requirement for heating. U_o and U_w are specified in units of:

$$\frac{\text{Btu}}{\text{hr} \bullet \text{ft}^2 \bullet {}^\circ\text{F}}$$

502.3.2 Slab on Grade Floors: For slab on grade floors the thermal resistance of the insulation around the perimeter of the floor shall not be less than the value given in Table 5-2.

502.3.3 Alternative Wall Allowance for Other Than Group R Occupancies: For other than Group R Occupancies, three stories or less, the maximum allowed value for average thermal transmittance (U_o) of the exterior walls may be increased to the values given in Table 5-2 BUILDINGS OVER THREE CONDITIONED STORIES provided that at least one of the following criteria is also met:

1. Mechanical supply of outside air and mechanical exhaust of building air shall be automatically shut off and the duct closed for at least eight hours per day during hours of nonoccupancy, or
2. The primary source of heating for the building shall be one or more heat pumps meeting the provisions of section 503.4.2 or gas or oil combustion heating equipment with a minimum combustion efficiency of eighty-five percent for central heating plants and eighty percent for room and space heaters. This efficiency shall be determined in accordance with the provisions of section 503.4.3.

Provided further: That if both criteria are met, the maximum allowed value for thermal transmittance (U_o) of the exterior walls used in Table 5-2 may be increased by 0.05 in determining compliance with the provisions of the Code.

For walls with a wall weight of at least thirty pounds per ft^2 (provided that walls constructed of hollow masonry units have cores filled with either grout, concrete, or with an insulating material with resistance per inch (R-value) of at least 2.25 $ft^2/hr \bullet {}^\circ F/Btu$) the calculated thermal resistance of the wall sections measured face to face on wall units which are exposed to inside air temperatures, not including the thermal resistance of air films or additional exterior wall elements may be increased by twenty-five percent in determining compliance with the provisions of the Code provided that:

Heating and cooling set-point temperatures in the conditioned spaces or zones of the building shall be separated by at least 5°F. The temperature control shall be designed to prevent new energy from being used to heat the space above the heating set-point temperature or cool the space below the cooling set-point temperature.

502.4 Air Leakage for All Occupancies

502.4.1: 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: 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: 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.

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 lights 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 one half 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 seventy-five 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 and 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 one hundred and fifty percent 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 fifty-six thousand Btu/h or less may exceed the one hundred-fifty percent sizing limit provided that the installed equipment has an annual fuel utilization efficiency (AFUE) of not less than the sum of seventy-eight percent plus one percent for every five thousand 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: Each temperature control zone shall include thermostatic controls installed and operated to sequence the use of heating and cooling energy to satisfy the thermal and/or humidity requirement of the zone. Controls shall prevent reheating (heating air that is cooler than system mixed air), recooling (cooling air that is warmer than the system mixed air), mixing or simultaneous supply of warm air (warmer than system return air mixed air) and cold air (cooler than system mixed air), or other simultaneous operation of heating and cooling systems to one zone. For the purposes of this section, system mixed air is defined as system return air mixed with the minimum ventilation air requirement by section 303.

Exceptions:

1. Variable air volume systems designed to reduce the air supply to each zone during periods of occupancy to the larger of the following:
   a. Thirty percent or less of the peak supply volume.
   b. The minimum allowed to meet ventilation requirements of section 303.
   c. 0.5 cfm/ft^2 of zone conditioned area before reheating, recooling or mixing takes place. Consideration shall be given to supply air temperature reset control.
2. The energy for reheating, or providing warm air in mixing systems, is provided entirely from recovered energy that would otherwise be wasted, or from renewable energy sources. In addition, the system shall comply with section 503.7 without exception.
3. Areas where specific humidity levels are required to satisfy process needs.
4. Where special pressurization relationships or cross-contamination requirements are such that variable air volume systems are impractical, supply air temperatures shall be reset by representative building load or outside air temperature.

503.4 HVAC Equipment Performance Requirements

503.4.1 Equipment Components

503.4.1.1: 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: 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: 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.

503.4.2.3 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). For all Other Occupancies, all gas and oil-fired central heating plants shall have a minimum combustion efficiency of not less than that shown in Table 5-3.

* 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: 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.

Exception: These requirements do not apply to equipment used for refrigerated food or florists' and nurseries' coolers.

503.4.5 Applied HVAC System Components, Electrically Operated, Cooling Mode: HVAC System components, as listed in Table 5-9, whose energy input is entirely electric, shall have an energy efficiency ratio (EER) or a Coefficient of Performance (COP) cooling not less than the values in Table 5-9.

503.4.6 HVAC System Equipment - Heat Operated, Cooling Mode, Efficiency Limitation, Equipment: Heat-operated cooling equipment shall have a COP cooling not less than the values in Table 5-10.

503.5 Transport Energy

503.5.1 All-air Systems: The air transport factor for each all-air system shall be not less than 5.5. The factor shall be based on design system air flow for constant volume systems. The factor for variable air volume systems may be based on average conditions of operation. Energy for transfer of air through heat recovery devices shall not be included in determining the factor; however, such energy shall be included in the evaluation of the effectiveness of the heat recovery system.

$$\text{Air Transport Factor} = \frac{\text{Space Sensible Heat Removal}^*}{\text{Supply + Return Fan(s) Power Input}^*}$$

*Expressed in Btu/h or watts

503.5.2 Other Systems: Air and water, all-water and unitary systems employing chilled, hot, dual-temperature or condenser water transport systems to space terminals shall not require greater transport energy (including central and terminal fan power and pump power) than an equivalent all-air system providing the same space sensible heat removal and having an air transport factor not less than 5.5.

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): Each fan system shall be designed to use up to and including one hundred percent 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 three thousand five hundred cfm or total cooling capacity is less than ninety thousand 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 one hundred percent 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 one hundred percent 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.

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 thirty percent.

Exception: Special occupancies 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. Spaces other than living units shall meet the requirements of 503.8.3.3.

503.8.3.3 Other Types of Buildings or Occupancies: At least one thermostat for regulation of space temperature shall be provided for:

1. Each separate system.
2. Each separate zone as defined in Chapter 2. As a minimum, each floor of a building shall be considered as a separate zone. In a multistory building where the perimeter system offsets only the transmission losses of the exterior wall, an entire side of uniform exposure may be zoned separately. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each floor.

503.8.3.4 Control Setback and Shut-Off:

1. **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.
2. **Other Buildings and Occupancies.** Each HVAC system shall be equipped with a readily accessible, automatic means of shutting off or reducing the energy used for HVAC during periods of non-use or alternate uses of the building spaces or zones served by the system. The following are examples that meet this requirement:
   a. Manually adjustable automatic timing devices.
   b. Automatic control systems.

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: High-pressure and medium-pressure ducts shall be leak tested in accordance with the applicable standards 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: 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: 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.

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

503.11.1 Other Insulation Thickness: Insulation thickness in Table 5-12 is based on insulation having thermal resistance in the range of 4.0 to 4.6 per inch of thickness on a flat surface at a mean temperature of 75°F. Minimum insulation thickness shall be increased for materials having R-values less than 4.0 per inch, or may be reduced for materials having R-values greater than 4.6 per inch.

a. For materials with thermal resistance greater than R = 4.6 per inch, the minimum insulation thickness may be reduced as follows:

$$\frac{4.6 \times (\text{Table 5-12 Thickness})}{\text{Actual Resistance}} = \text{New Minimum Thickness}$$

b. For materials with thermal resistance less than R = 4.0 per inch, the minimum insulation thickness shall be increased as follows:

$$\frac{4.0 \times (\text{Table 5-10 Thickness})}{\text{Actual Resistance}} = \text{New Minimum Thickness}$$

c. Additional insulation with vapor barriers shall be provided to prevent condensation where required by the building official.

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.

504.2.2 Insulation: Heat loss from unfired hot-water storage tanks shall be limited to a maximum of 9.6 Btu/hr/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 = probably 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 twenty-four 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: 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 51-26 WAC, as measured with both hot and cold faucets turned on to their maximum flow.

504.8.2 Lavatories in Rest Rooms of Public Facilities

504.8.2.1: Lavatories in restrooms of public facilities shall be equipped with a metering valve designed to close by spring or water pressure when left unattended (self-closing) and limit the flow rate as set forth in chapter 51-26 WAC.

Exception: Separate lavatories for physically handicapped persons shall not be equipped with self-closing valves.

504.8.2.2: Lavatories in restrooms of public facilities shall be equipped with devices which limit the outlet temperature to a maximum of 110°F.

SECTION 505 -- ELECTRICAL POWER AND LIGHTING

505.1 General: Electrical distribution and lighting systems shall be designed for efficient distribution and use of electrical energy from the service entrance to and at the points of use as provided herein.

505.2 Lighting Switching: Switching for building lighting systems shall be designed and installed to permit efficient use of energy and to permit maximum flexibility in the use of the installed lighting. The following mandatory requirements represent the minimum lighting controls to be installed in any building. Additional controls should be provided where deemed appropriate and where the installation of such controls can significantly reduce energy consumption.

a. All lighting controls, except automatic controls or those for special purpose applications which require trained operators or those which would pose a safety problem or a security hazard, shall be installed so as to be readily accessible to personnel occupying or using the lighting space.
b. The maximum lighting power that may be controlled from a single switch or automatic control shall not exceed that provided by a twenty ampere circuit loaded to no more than eighty percent. A master control may be installed provided the individual switches retain their capability to function independently.
c. All lighted spaces enclosed by walls or ceiling height partitions and with floor area less than four hundred square feet shall be provided an individual lighting control or an occupant-sensing automatic control.
d. All lighted spaces with floor area greater than four hundred square feet shall be provided with controls to permit reducing the lighting by not more than one half or occupant-sensing automatic controls.
e. All building areas greater than two hundred square feet where natural lighting is available shall be provided with individual controls or daylight- or occupant-sensing automatic controls which permit control of lights independent of general area lighting. Either individual controls shall be provided for each row of luminaires parallel to a window wall or controls shall be provided to reduce the lighting in at least two steps to not more than one-half and to completely off in the natural lighting area. For office and school occupancies, at a minimum, lighting serving a zone within twelve feet of a window wall or the zone between an interior wall and the window wall of less than twelve feet shall comply with this provision. For retail occupancies, at least the row of luminaires nearest the window shall comply with this provision.
f. All display, exhibition, or specialty lighting shall be controlled independently of general area lighting.
g. All exterior building lighting including facade lighting, parking lots, driveways, walkways shall be furnished with automatic controls to reduce or turn off all lights during periods of non-use or daylight hours, except those required for safety and security. Sign lights shall be exempt from this provision.

505.3 Lighting Power Budget: A lighting power budget is the upper limit of the power to be available to provide the lighting needs in accordance with the criteria and calculation procedure specified herein.

The lighting power budget for a building shall be the sum of the power limits computed for all lighted interior and exterior spaces and shall be determined in accordance with the procedures specified in this section.

Exception: One- and two-family detached dwellings and the dwelling portion of multifamily buildings are exempt from the requirements of section 505.3.

505.3.1 Budget Development: The installed lighting wattage for the building project shall not exceed the budget level calculated in this section. The budget wattage level shall be the sum of the interior budget calculated and the exterior budget. Lighting wattage includes lamp and ballast wattage.

505.3.2 Building Interiors: The interior lighting budget shall be calculated by multiplying the gross conditioned floor area, in square feet, by the appropriate unit power budget, in watts per square foot, specified in Table 5-13.

For special conditions when approved by the building official, calculation based on Illuminating Engineering Society Unit Power Density or similar nationally recognized standards may be used.

The lighting power budget shall be based on the primary occupancy for which the space within the building is intended. If multiple occupancies are intended, the lighting power budget for each type of occupancy shall be separately calculated and summed to obtain the lighting budget for the interior spaces of the building. If a common circulation area serves multiple occupancies or multiple retail spaces, the lighting power budget for the common circulation area shall be the weighted average of the lighting power budgets for all other areas on that floor. In cases where a lighting plan for only a portion of a building is submitted, the interior lighting budget shall be based on the gross floor area covered by the plan.

Exceptions:

1. Where the following automatic lighting controls are installed, for calculations used to determine Code compliance, the installed lighting wattage may be reduced by the following percentages:
   a. For occupant-sensing devices, energy savings of thirty percent shall be allowed for any single space up to four hundred ft^2 and enclosed by ceiling height partitions; classrooms, conference rooms, computer rooms, storage areas, corridors, or waiting rooms.
   b. For daylighting controls, energy savings of thirty percent for continuous dimming and twenty percent for stepped controls shall be allowed for any daylit space.
   c. For lumen maintenance controls, energy savings of ten percent shall be allowed for any space.
   d. For daylighting controls with occupant-sensing devices, energy savings of forty-four percent shall be allowed for any single space up to four hundred ft^2 within daylit spaces, and enclosed by ceiling height partitions.
   e. For occupant-sensing devices with lumen maintenance controls, energy savings of thirty-seven percent shall be allowed for any single space up to four hundred ft^2 and enclosed by ceiling height partitions.

505.3.2.1: Lighting for the following applications shall be exempted from inclusion in the calculation of lighting power budgets:

A. Stage lighting, entertainment, or audiovisual presentations where the lighting is an essential technical element for the function performed.
B. Lighting for medical and dental tasks.
C. Lighting in areas specifically designed for visually handicapped people.
D. For restaurant occupancies, lighting for kitchens and food preparation areas.

505.3.4 Building Exteriors: The exterior lighting budget shall be calculated by multiplying the building perimeter in feet by 7.5 watts per foot. Lighting for parking structures shall be calculated at 0.3 watts per gross square foot of parking area. An allowance for outdoor surface parking and circulation lighting may be added at 0.05 watts per ft^2 of area. Lighting for signs that are not an integral part of the building shall be exempted from inclusion in these calculations.

EQUATION 1 – GROUP R OCCUPANCY

TARGET UA

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

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_G = the thermal transmittance value of the glazing area found in Table 5-1.

A_G = .15 (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-value 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 = .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

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

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.

U_{BGW} = the thermal transmittance value of the below grade opaque wall area.

A_{BGW} = opaque below grade wall area.

A_W = opaque wall area.

U_G = the thermal transmittance of the glazing (window or skylight) area.

A_G = glazing area, including windows in exterior doors.

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 -- OTHER THAN GROUP R OCCUPANCY

TARGET U_o

$$U_o = \frac{U_W A_W + U_F A_F + U_C A_C + F_S P_S}{A_W + A_F + A_C + P_S}$$

Where:

U_o = 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 5-2.

A_W = opaque above grade wall area.

U_F = the thermal transmittance value of the floor area found in Table 5-2.

A_F = floor area over unconditioned space.

U_C = the thermal transmittance value of the ceiling area found in Table 5-2.

A_C = ceiling area.

F_S = concrete slab component F-value found in Table 5-2.

P_S = lineal ft. of concrete slab perimeter

EQUATION 5 -- OTHER THAN GROUP R OCCUPANCY

PROPOSED U_o

$$U_o = \frac{U_W A_W + U_{BGW} A_{BGW} + U_G A_G + U_F A_F + U_{RC} A_{RC} + U_{CC} A_{CC} + U_D A_D + F_S P_S}{A_W + A_{BGW} + A_G + A_F + A_{RC} + A_{CC} + A_D + P_S}$$

Where:

U_o = 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.

U_{BGW} = the thermal transmittance value of the below grade opaque wall area.

A_{BGW} = opaque below grade wall area.

A_W = opaque wall area.

U_G = the thermal transmittance of the glazing (window or skylight) area.

A_G = glazing area, including windows in exterior doors.

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 = thermal transmittance value of 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:

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

TABLE 5-1
TARGET COMPONENT VALUES FOR GROUP R OCCUPANCY

Climate Zone⇒	Electric Resistance 1	Electric Resistance 2	Other Fuels 1	Other Fuels 2
Component				
Glazing % Floor Area	15%	15%	15%	15%
Glazing U-Factor	U = 0.400	U = 0.400	U = 0.650	U = 0.600
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 (R = 19)	U = 0.062 (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	U = 0.043	U = 0.043	U = 0.043	U = 0.043
Slab	F = .69	F = .69	F = .69	F = .69
3.5' Depth: Walls	U = 0.041	U = 0.041	U = 0.041	U = 0.041
Slab	F = 0.64	F = 0.64	F = 0.64	F = 0.64
7' Depth: Walls	U = 0.037	U = 0.037	U = 0.037	U = 0.037
Slab	F = 0.57	F = 0.57	F = 0.57	F = 0.57
Below Grade Exterior				
Wall R-Value	(R = 10)	(R = 12)	(R = 10)	(R = 12)
2' Depth: Walls	U = 0.070	U = 0.061	U = 0.070	U = 0.061
Slab	F = 0.60	F = 0.60	F = 0.60	F = 0.60
3.5' Depth: Walls	U = 0.064	U = 0.057	U = 0.064	U = 0.057
Slab	F = 0.57	F = 0.57	F = 0.57	F = 0.57
7' Depth: Walls	U = 0.056	U = 0.050	U = 0.056	U = 0.050
Slab	F = 0.42	F = 0.42	F = 0.42	F = 0.42

TABLE 5-2
COMPONENT REQUIREMENTS FOR OTHER THAN GROUP R OCCUPANCIES

BUILDINGS OF THREE CONDITIONED STORIES OR LESS

Zone	Ceilings	Walls (Includes Glazing)	Floors	Slab on Grade[1]	
	U_o	U_o	U_o	Installed R-Value	Installed F-Value
I.	0.035	0.25	0.05	7	0.56
II.	0.035	0.20	0.05	10	0.54

[1] Insulation shall be water-resistant material manufactured for this use.

BUILDINGS OVER THREE CONDITIONED STORIES

Zone	Ceilings	Walls (Includes Glazing)	Floors	Slab on Grade[1]	
	U_o	U_o	U_o	Installed R-Value	Installed F-Value
I.	0.08	0.30	0.08	7	0.56
II.	0.06	0.25	0.08	10	0.54

[1] Insulation shall be water-resistant material manufactured for this use.

TABLE 5-3
OTHER THAN GROUP R OCCUPANCY HVAC SYSTEM
HEATING EQUIPMENT - GAS- AND OIL-FIRED
MINIMUM STEADY STATE COMBUSTION EFFICIENCY

Types of Equipment	Furnaces of Capacity of 225,000 Btu/h and less Boilers of Capacities of 300,000 Btu/h and less Percent[1]	All Other Commercial/ Industrial Furnace and Boilers Percent[2]
Forced-air furnaces and low-pressure steam or hot-water boilers	74	75
Gravity central furnaces	69	-
All other vented heating equipment	69	-

[1] Combustion efficiency for furnaces of capacities of 225,000 Btu/h and less and boilers of capacities of 300,000 Btu/h and less shall be tested in accordance with the applicable U.S. Department of Energy furnace test procedures.

[2] Combustion efficiency of commercial/industrial furnaces and boilers is defined as 100 percent minus stack losses in percent of heat input.

Stack losses are:

Loss due to sensible heat in dry flue gas.
Loss due to incomplete combustion.
Loss due to sensible and latent heat in moisture formed by combustion of hydrogen in the fuel.

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

CONDITIONS	TYPE		
	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 incooling

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°	67°	----	-----
Condenser ambient (air cooled)	°F	95°	75°	-----	-----
Condenser water (water cooled)	°F	---	---	85°	95°

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 (air/evap. cooled) °F	95°F (dry bulb) /75°F (wet bulb)	--
Compressor saturated discharge temperature		
Water cooled (evap. cooled) °F	--	105°
Air cooled °F	--	120°

Standard ratings at sea level.

* $hr \bullet ft^2 \bullet °F/Btu$

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/hr. (19,050 watts)			
A. Split System	10.0	---	---
B. Single Package[3]	9.7	---	9.3[1]
65,000 Btu/hr. 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
MINIMUM EFFICIENCY FOR ELECTRIC HVAC COMPONENTS[1,2]

WATER CHILLING PACKAGES

CONDENSING MEANS

TYPE OF COMPONENT	COMPRESSOR TYPE	AIR EER	AIR COP	WATER EER	WATER COP	EVAP. EER	EVAP. COP
Condenser Included	Centrifugal or rotary	8.00	2.34	13.80	4.04	--	--
	Reciprocating	8.40	2.36	12.00	3.51	--	--
Condenserless	Reciprocating	9.90	2.90	12.00	3.51	--	--
Compressor and condenser units 65,000 Btu/hr (19,000 watts) and over[2]	Positive displacement	9.50	2.78	12.50	3.66	12.50	3.66

HYDRONIC HEAT PUMPS

Water source under 65,000 Btu/hr (19,000 watts)	Centrifugal or rotary	9.00	2.64
Water source 65,000 Btu/hr (19,000 watts) and over	Centrifugal or rotary	9.40	2.75

[1] When tested at the standard rating conditions specified in Table 5-6.

[2] Ratings in accordance with Standard RS-14 as applicable.

TABLE 5-10
HVAC-SYSTEM HEAT OPERATED COOLING EQUIPMENT

HEAT SOURCE	MINIMUM COP
Direct Fired (gas, oil)	0.48
Indirect Fired (steam, hot water)	0.68

$$\text{Minimum COP} = \frac{\text{Net Cooling Output}}{\text{Total heat input}^1}$$

[1] electrical auxiliary inputs excluded

TABLE 5-11
INSULATION OF DUCTS

DUCT LOCATION	CLIMATE ZONE	INSULATION TYPES MECHANICALLY COOLED	INSULATION TYPES HEATING ONLY	GROUP R OCCUPANCY HEATING OR COOLING DUCTS
On roof or on exterior of building	I	C, V[2] and W	C and W	E and W
	II	D, V[2] and W	D and W	D and W
Attic, garage, crawl space, in walls[1], in floor/ceiling[1]	I	B and V[2]	B	E
	II	C and V[2]	C	E
Within the conditioned space or in heated basements		None Required	None Required	None Required
In cement slab or in ground		A	B	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*

PIPING SYSTEM	FLUID TEMP RANGE (°F)	INSULATION THICKNESS FOR GIVEN PIPE DIAMETERS[1] LESS THAN 12 FOOT PIPE RUN[2] UP TO 2"	1" AND LESS	GREATER THAN 1" TO 2"	GREATER THAN 2" TO 4"	GREATER THAN 4" TO 6"	GREATER THAN 6" AND LARGER
HEATING & HOT WATER SYSTEMS							
Steam & Hot Water Pressure/temperature							
High	306°F – 450°F	1.5"	2.5"	2.5"	3.0"	3.5"	3.5"
Medium	251°F – 305°F	1.5"	2.0"	2.5"	2.5"	3.0"	3.0"
Low	201°F – 250°F	1.0"	1.5"	1.5"	2.0"	2.0"	2.0"
All Other	100°F – 200°F	0.5"	1.0"	1.0"	1.5"	1.5"	1.5"
Steam Condensate (for feed water)	Any	1.0"	1.0"	1.5"	2.0"	2.0"	2.0"
COOLING SYSTEMS							
Chilled Water	40°F – 55°F	0.5"	0.5"	0.75"	1.0"	1.0"	1.0"
Refrigerant/brine	Below 40°F	1.0"	1.0"	1.5"	1.5"	1.5"	1.5"

[1] For piping exposed to ambient air, increase thickness by 0.5".
[2] Pipe runouts not exceeding 12 feet in length to individual units, with a pipe diameter of less than 2 inches.
* Column headings for pipe diameters amended 5/30/90.

TABLE 5-13 LIGHTING POWER BUDGET[1]

GROUP OCCUPANCY	DESCRIPTION	LIGHTING POWER BUDGET[3] (Watts/ft²)
A	Assembly w/stage	1.1
	Stage lighting	Exempt
	Assembly w/o stage; other than B and E	1.1
B	Gasoline service station	1.7
	Storage garages	0.3
	Office buildings	1.7
	Wholesale stores	2.0
	Police and fire stations	1.7
	Retail stores:	
	less than 6000 ft²	4.0
	6000 to 20,000 ft²	3.0
	over 20,000 ft²	2.0
	Drinking and dining establishments	1.85
	Food preparation task light	Exempt
	Aircraft hangars - storage	0.7
	Process plants[4]	1.0
	Factories and work shops[4]	1.7
	Storage structures	0.7
E	Schools and daycare centers	1.7
	Audio-visual presentation lighting	Exempt
H	Storage structures	0.7
	Handling areas	1.7
	Paint shops	2.5
	Auto repair shops	1.7
	Aircraft repair hangars	1.7
I	Institutions	1.7
	Administrative support areas	1.7
	Diagnostic, treatment, food service task lighting	Exempt
R	Dwelling units	Exempt
	Food preparation task lighting	Exempt

[1] Watts/ft² of room may be increased by two percent per foot of height above 20 feet.

[2] Emergency exit lighting is exempt from interior lighting budget.

[3] Lighting that is part of machines or equipment is exempt from this budget.

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 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 for Group R Occupancy, or Table 6-7 for Other Occupancies. Installed components shall meet the requirements of section 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: For all doors which are less than fifty percent glazing, including fire doors, the opaque door area shall have a maximum area weighted average U-value not exceeding that shown in Tables 6-1 to 6-6 and the glazing shall comply with section 602.7. U-values for the opaque door area shall be determined in accordance with section 502.1.5.1. For all doors which are fifty percent or more glazing, the entire door area shall comply with the glazing requirements in section 602.7.

Exception: Doors whose area and U-value are included in the calculations for compliance with the requirements for glazing in section 602.7 shall be exempt from the U-value requirements stated above.

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 doors using the exception of section 602.6.

602.7.2 Glazing U-Value: The total glazing area as defined in Chapter 2 shall have an area weighted average U-value not to exceed that specified in Tables 6-1 to 6-6. U-values for glazing shall be determined in accordance with section 502.1.5.1. These areas and U-values shall also include any doors using the exception of section 602.6.

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

Exception: Single glazing for ornamental, security, or architectural purposes 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 is one percent 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.

SECTION 604 -- ELECTRIC POWER AND LIGHTING FOR GROUP R OCCUPANCY

604.1: All electrical power and lighting systems shall comply with the requirements of section 505.

SECTION 605 -- BUILDING ENVELOPE REQUIREMENTS FOR OTHER THAN GROUP R OCCUPANCIES

605.1 Opaque Envelope Criteria: Roof/ceilings, exterior walls, floors over unconditioned space, below grade walls, and slab on grade floors enclosing heated spaces shall be insulated to not less than the nominal R-value specified for roof/ceilings, exterior walls, floors over unconditioned space, below grade walls, and slab on grade floors, respectively, in Table 6-7. Roof/ceilings enclosing mechanically cooled spaces shall be insulated to not less than the nominal R-value specified for roof/ceilings in Table 6-7.

605.2 Glazing Criteria: All glazing shall be, at a minimum, double glazing. Insulating glass with at least one-half inch air space or approved storm sash will be considered as complying. The total glazing area shall not exceed the percentage of gross exterior wall area specified in Table 6-7.

Exception: Single glazing in doors may be installed provided that the glazing area is doubled for the purpose of demonstrating compliance with the glazing area requirements.

605.3 Air Leakage: All buildings shall comply with the air leakage requirements of section 502.4.

SECTION 606 -- BUILDING MECHANICAL SYSTEMS REQUIREMENTS FOR OTHER THAN GROUP R OCCUPANCIES

All building mechanical systems shall comply with the requirements of section 503.

SECTION 607 -- SERVICE WATER HEATING REQUIREMENT FOR OTHER THAN GROUP R OCCUPANCIES

All service water heating systems shall comply with the requirements of section 504.

SECTION 608 -- ELECTRICAL POWER AND LIGHTING REQUIREMENTS FOR OTHER THAN GROUP R OCCUPANCIES

All electrical power and lighting systems shall comply with the requirements of section 505.

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

OPTION	GLAZING % FLOOR AREA	GLAZING U-VALUE	DOORS U-VALUE	CEILING[2]	VAULTED CEILING[3]	WALL ABOVE GRADE	WALL[4,5] BELOW GRADE	WALL[4,6] BELOW GRADE	FLOOR[7]	SLAB[8] ON GRADE
I.	10%	0.46	0.40	R-38	R-30	R-21	R-21	R-10	R-30	R-10
II.	12%	0.43	0.20	R-38	R-30	R-19	R-19	R-10	R-30	R-10
III.	12%	0.40	0.40	R-38	R-30	R-21	R-21	R-10	R-30	R-10
IV.[9]	15%	0.40	0.20	R-38	R-30	R-19	R-19	R-10	R-30	R-10
V.	18%	0.39	0.20	R-38	R-30	R-21	R-21	R-10	R-30	R-10
VI.	21%	0.36	0.20	R-38	R-30	R-21	R-21	R-10	R-30	R-10
VII.[9]	25%	0.32[10]	0.20	R-38	R-30	R-19+R5[11]	R-21	R-10	R-30	R-10
VIII.[9]	30%	0.29[10]	0.20	R-38	R-30	R-19+R5[11]	R-21	R-10	R-30	R-10

[1] Reference Case

[2] Minimum requirements for each option listed. For example, if a proposed design has a glazing ratio in 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.

[3] Requirement applies to all ceilings except single rafter or joist vaulted ceilings. 'Adv' denotes Advanced Framed Ceiling.

[4] Requirement applicable only to single rafter or joist vaulted ceilings.

[5] 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.

[6] Floors over crawl spaces or exposed to ambient air conditions.

[7] 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.

[8] 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.

[9] This wall insulation requirement denotes R-19 wall cavity insulation plus R-5 foam sheathing.

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

OPTION	HVAC[2] EQUIP. EFFIC.	GLAZING % FLOOR AREA	GLAZING U-VALUE	DOORS U-VALUE	CEILING[3]	VAULTED CEILING[4]	WALL ABOVE GRADE	WALL•int[5] BELOW GRADE	WALL•ext[5] BELOW GRADE	FLOOR[6]	SLAB[7] ON GRADE
I.	Med.	10%	0.70	0.40	R-30	R-30	R-15	R-15	R-10	R-19	R-10
II.	Med.	12%	0.65	0.40	R-30	R-30	R-15	R-15	R-10	R-19	R-10
III.	High	21%	0.75	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
IV.[8]	Med.	21%	0.65	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
V.	Low	21%	0.60	0.40	R-30	R-30	R-19	R-19	R-10	R-19	R-10
VI.[9]	Med.	25%	0.45[9]	0.40	R-38	R-30	R-19	R-19	R-10	R-25	R-10
VII.[9]	Med.	30%	0.40[9]	0.40	R-30	R-30	R-19	R-19	R-10	R-25	R-10

[1] Reference Case

[2] 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.

[3] Requirement applies to all ceilings except single rafter or joist vaulted ceilings. "Adv" denotes Advanced Framed Ceiling.

[4] Requirement applicable only to single rafter or joist vaulted ceilings.

[5] 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.

[6] Floors over crawl spaces or exposed to ambient air conditions.

[7] 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.

[8] 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.

[9] This wall insulation requirement denotes R-19 wall cavity insulation plus R-5 foam sheathing.

[10] 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.

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

OPTION	GLAZING % FLOOR AREA	GLAZING U-VALUE	DOORS U-VALUE	CEILING[2]	VAULTED CEILING[3]	WALL ABOVE GRADE	WALL•int[4] BELOW GRADE	WALL•ext[4] BELOW GRADE	FLOOR[5]	SLAB[6] ON GRADE
I.	10%	0.38	0.20	R-38	R-30	R-21	R-21	R-12	R-30	R-10
II.	12%	0.40	0.20	R-38	R-30	R-19+R-5[8]	R-21	R-12	R-25	R-10
III.[7]	15%	0.40	0.20	R-38	R-30	R-19+R-5[8]	R-21	R-12	R-30	R-10
IV.	18%	0.38	0.20	R-38	R-30	R-19+R-5[8]	R-21	R-12	R-30	R-10
V.[7]	21%	0.35	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]	0.20	R-49Adv	R-38	R-19+R-5[8]	R-21	R-12	R-30	R-10
VII.[7]	30%	0.28[7]	0.20	R-60Adv	R-38	R21+R7.5[9]	R-21	R-12	R-30	R-10

[1] Reference Code

[2] 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.

[3] Requirement applies to all ceilings except single rafter or joist vaulted ceilings. 'Adv' denotes Advanced Framed Ceiling.

[4] Requirement applicable only to single rafter or joist vaulted ceilings.

[5] 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.

[6] Floors over crawl spaces or exposed to ambient air conditions.

[7] 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.

[8] 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.

[9] This wall insulation requirement denotes R-19 wall cavity insulation plus R-5 foam sheathing.

[10] This wall insulation requirement denotes R-21 wall cavity insulation plus R-7.5 foam sheathing.

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

OPTION	HVAC[2] EQUIP. EFFIC.	GLAZING % FLOOR AREA	GLAZING U-VALUE	DOORS U-VALUE	CEILING[3]	VAULTED CEILING[4]	WALL ABOVE GRADE	WALL[5] BELOW GRADE	WALL[6] BELOW GRADE	FLOOR[7]	SLAB[8] ON GRADE
I.	Med.	10%	0.70	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
II.	Med.	12%	0.65	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
III.	High	17%	0.65	0.40	R-38	R-30	R-19	R-19	R-12	R-25	R-10
IV.*	Med.	17%	0.60	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
V.	Low	17%	0.50	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VI.	Med.	21%	0.50	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VII.	Med.	25%	0.40[9]	0.40	R-38	R-30	R-19	R-19	R-12	R-30	R-10
VIII.	Med.	30%	0.40[9]	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 in the conditioned floor area of 19%, it shall comply with all of the requirements of the 21% glazing optionfor 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: 0.45 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.

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

OPTION	AVERAGE[2] LOG THICKNESS	GLAZING % FLOOR AREA	GLAZING U-VALUE	DOORS U-VALUE	CEILING[3]	VAULTED[4] CEILING	FLOOR[5]	SLAB[6] ON GRADE
CLIMATE ZONE 1								
I.[7]	5.5"	15%	0.31	0.14	R-60 Adv	R-38	R-38	R-10
II.[7]	7.5"	15%	0.40	0.20	R-60 Adv	R-38	R-30	R-10
III.*	9.6"	15%	0.40	0.20	R-38	R-30	R-30	R-10
CLIMATE ZONE 2								
IV.[7]	6.7"	15%	0.31	0.14	R-60 Adv	R-38	R-38	R-10
V.[7]	8.7"	15%	0.40	0.14	R-60 Adv	R-38	R-38	R-10
VI.[7]	9.8"	15%	0.40	0.20	R-60 Adv	R-38	R-30	R-10
VII.[7]	10.5"	15%	0.40	0.20	R-49 Adv	R-38	R-30	R-10
VIII.*	13.5"	15%	0.40	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.

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

OPTION	AVERAGE[2] LOG THICKNESS	GLAZING % FLOOR AREA	GLAZING U-VALUE	DOORS U-VALUE	CEILING[3]	VAULTED[4] CEILING	FLOOR[5]	SLAB[6] ON GRADE
CLIMATE ZONE 1								
I.[7]	3.5"	21%	0.40	0.39	R-49 Adv	R-38	R-30	R-10
II.	4.4"	21%	0.40	0.40	R-38	R-30	R-19	R-10
III.	5.2"	21%	0.50	0.40	R-38	R-30	R-19	R-10
IV.	6.5"	21%	0.60	0.40	R-38	R-30	R-19	R-10
V.	7.0"	21%	0.60	0.40	R-38	R-30	R-19	R-10
VI.*	8.2"	21%	0.65	0.40	R-38	R-30	R-19	R-10
CLIMATE ZONE 2								
VII.[7]	3.5"	17%	0.31	0.14	R-60 Adv	R-38	R-38	R-10
VIII[7,8]	3.5"	17%	0.40	0.40	R-60 Adv	R-38	R-30	R-10
IX.[7]	4.6"	17%	0.40	0.40	R-60 Adv	R-38	R-30	R-10
X.	5.4"	17%	0.40	0.40	R-38	R-30	R-30	R-10
XI.	6.8"	17%	0.50	0.40	R-38	R-30	R-30	R-10
XII.*	9.0"	17%	0.60	0.40	R-38	R-30	R-30	R-10

Reference Case

[1] For Group R Occupancy use Table 6-6 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] For this option, minimum HVAC system efficiency is an AFUE of 0.88.

TABLE 6-7 OTHER THAN GROUP R OCCUPANCIES PRESCRIPTIVE REQUIREMENTS

COMPONENT	ZONE I	ZONE II
SPACE CONDITIONING SYSTEM TYPE	ANY	ANY
ROOF/CEILINGS	R-30	R-30
EXTERIOR WALLS	R-11	R-11
FLOORS OVER UNCONDITIONED SPACE	R-11	R-11
BELOW GRADE WALLS	R-4	R-5
SLAB ON GRADE FLOORS[1]	R-7	R-10
GLAZING TYPE	Double[2]	Double[2]
MAXIMUM TOTAL GLAZING AREA (% of Gross Exterior Wall Area)	32%	22%

[1] Insulation shall be a water-resistant material, manufactured for its intended use, and installed to manufacturer's specifications.

[2] 'Double' denotes a minimum air space between glazings of 1/2 inch.

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	1989 ASHRAE Handbook of Fundamentals.
RS-2	Standard Method of Test for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors, Specification E283-84 of ASTM. Specifications for Aluminum Windows, ANSI A134.1, 1972 Specifications for Aluminum Sliding Glass Doors, ANSI A134.2, 1972. Industry Standard for Wood Window Units, NWWDA IS-2-87, Industry Standard for Wood Sliding Patio Doors, NWWDA IS-3-88.
RS-2B	AAMA 1503.1-88, 1988 Voluntary Test Method for Thermal Transmittance of Windows, Doors and Glazed Wall Sections.
RS-2C	ASTM C236-87 Test for Thermal Conductance and Transmittance of Built-Up Sections by Means of a Guarded Hot Box; and ASTM C976-82 Thermal Performance of Building Assemblies by Means of the Calibrated Hot Box.
RS-3	ASHRAE Standard 62-89 Ventilation for Acceptable Indoor Air Quality.
RS-4	ASHRAE Standard 55-81 Thermal Environmental Conditions for Human Occupancy.
RS-5	DOE Test Procedures for Water Heaters, 10 CFR Part 430 Appendix E to Subpart B.
RS-6	Household Automatic Electric Storage-Type Water Heaters, ANSI C72.1-1972.
RS-7	Gas Water Heaters, Volume III, Circulating Tank, Instantaneous and Large Automatic Storage-Type Water Heaters, ANSI Z21.10.3, 1974.
RS-8	IES Lighting Handbook, Illuminating Engineering Society, 1984 Reference Volume, 1987 Application Volume.

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, ARI Standard 310-87.

RS-11 1987 ASHRAE HVAC Systems and Applications Handbook.

RS-12 Energy Calculations I: Procedures for Determining Heating and Cooling Loads for Computerizing Energy Calculations--Algorithms for Building Heat Transfer Subsystems, ASHRAE 1975.

RS-13 Energy Calculations II: Procedures for Simulating the Performance of Components and Systems for Energy Calculations, 3rd Edition, ASHRAE 1975.

RS-14 Standard for Positive Displacement Refrigerant Compressor and Condensing Units, ARI Standard 520-74.

RS-15 1988 ASHRAE Equipment Handbook.

RS-16 Heating and Air Conditioning Systems--Installation Standards, SMACNA, February, 1977.

RS-17 SMACNA Duct Metal and Flexible Construction Standards, 1st Edition, Washington, D.C., 1985.

RS-18 Same as Standard RS-17.

RS-19 SMACNA Fibrous Glass Duct Construction Standards, 6th Edition, Washington, D.C., 1990.

RS-20 1990 ASHRAE Refrigeration Volume.

RS-21 Standard for Package Terminal Heat Pumps, ARI Standard 380-90.

RS-22 ASTM E779-87 Standard Practice for Measuring Air Leakage by the Fan Pressurization Method.

RS-23 ASTM E741 Standard Practice for Measuring Air Leakage by the Tracer Dilution Method.

RS-24 Standard 24 CFR Part 3280 HUD.

RS-25 Thermal Bridge in Sheet Metal Construction from Appendix E of RS-9.

RS-26 Super Good Cents Technical Reference.

ACCREDITED AUTHORITATIVE AGENCIES

AAMA refers to the American Architectural Manufacturers Association, 35 East Wacker Drive, Chicago, IL 60601

ANSI refers to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018

ARI refers to the Air Conditioning and Refrigeration Institute, 1815 North Fort Myer Drive, Arlington, VA 22209

ASHRAE refers to the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329

ASTM refers to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103

IES refers to Illuminating Engineering Society, 345 East 47th Street, New York, NY 10017

NESCA refers to the National Environmental System Contractors Association, 1501 Wilson Blvd., Arlington, VA 22209

NWWDA refers to the National Wood Window and Door Association, 1400 East Toughy Avenue, Suite G-54, Des Plaines, IL 60018

SMACNA refers to the Sheet Metal and Air Conditioning Contractors National Association, Inc., 8224 Old Courthouse Rd., Tysons Corner, Vienna, VA 22180

CHAPTER 8

SECTION 800 -- SUGGESTED SOFTWARE FOR CHAPTER 4 SYSTEMS ANALYSIS APPROACH FOR GROUP R OCCUPANCY

PROGRAM NAME	SOURCE
CALPAS 3	BERKELEY SOLAR GROUP 455 Santa Clara Ave. Oakland, CA 94610 (415) 843-7600
DATACAL	SUNRISE ENERGY, INC. 5708 43rd Ave E. Tacoma, WA 98443 (206) 922-5218
DOE 2	ACROSOFT INT'L., INC. 9745 E. Hampten Av Suite 230 Denver, CO 80231 (303) 368-9225
F-LOAD	F-CHART SOFTWARE 4406 Fox Bluff Rd. Middleton, WI 53562 (608) 836-8536
MICROPAS	ENERCOMP 123 C Street Davis, CA 95616 (916) 753-3400
SUNDAY	ECOTOPE 2812 East Madison St. Seattle, WA 98112 (206) 322-3753
WATTSUN	WSEO 809 Legion Way SE. Olympia, WA 98504 Attn: Hank Date (206) 956-2031

CHAPTER 9

SECTION 900 -- 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 I

Electric Resistance	21 btu/hr • ft^2
Electric Resistance (Forced Air)	24 btu/hr • ft^2
Other Fuels (Forced Air)	27 btu/hr • ft^2

Climate Zone II

Electric Resistance	29 btu/hr • ft^2
Electric Resistance (Forced Air)	32 btu/hr • ft^2
Other Fuels (Forced Air)	39 btu/hr • ft^2

Example: A 1500 ft^2 house in Zone I, 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 1211.

CHAPTER 10

SECTION 1000 -- 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-values (BTU/°F•hr•ft^2 of wall area). Coefficients for below-grade slabs are listed as F-values (BTU/°F•hr per lineal foot of slab perimeter).

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

1002.2 Component Description: All below-grade walls are assumed to be eight 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 six inches of concrete wall extending above grade.

Interior insulation is assumed to be fiberglass batts placed in the cavity formed by 2x4 framing on twenty-four inch centers with one-half inch of 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 two, three and one-half, and seven 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-values, 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-VALUES AND SLAB F-VALUES FOR BASEMENTS

	Below Grade Wall U-value	Below Grade Slab F-value
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 six 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/Hr•°F•ft². Slabs two 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 two feet (or four 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 two feet (or four 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-values.

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-VALUES FOR ON-GRADE SLABS

Insulation type	R-0	R-5	R-10	R-15
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 (or Horiz. w/T.B.)	--	0.58	0.54	0.52
4-ft vertical (or Horiz. w/T.B.)	--	0.54	0.48	0.45
Fully insulated slab	--	--	0.36	--

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/°F•hr•ft² 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 one hundred feet of perimeter. The crawlspace is assumed to be two and one-half feet high, with twenty-four inches below grade and six inches above grade.

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

Vented crawlspaces: Assumed to have three air-changes per hour, with at least one ft² of net-free ventilation in the foundation for every three hundred 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 one ft² of net-free ventilation in the foundation for every three hundred 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 one-half inch of 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 sixteen inch centers, or post and beam on four by eight 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 twenty-four inches.

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

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

Nominal R-value		U-value	
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-VALUES FOR FLOORS OVER HEATED PLENUM CRAWLSPACES

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

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

SECTION 1005 -- ABOVE-GRADE WALLS

1005.1 General: Table 10-5 lists heat-loss coefficients for the opaque portion of above-grade walls (BTU/°F•hr•ft^2). 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 one-half inch gypsum wallboard, and on the outside with either beveled wood siding over one-half inch plywood sheathing or with five-eights 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 sixteen inch centers with double top plate and single bottom plate. Corners use three studs and each opening is framed using two studs. Headers consist of double 2X or single 4X material with an air space left between the header and the exterior sheathing. Interior partition wall/exterior wall intersections use two studs in the exterior wall.

Standard framing weighting factors:

Studs and plates	.19
Insulated cavity	.77
Headers	.04

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

Intermediate framing weighting factors:

Studs and plates	.18
Insulated cavity	.78
Headers	.04

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

Advanced Framing Weighting Factors:

Studs and plates	.13
Insulated cavity	.83
Headers	.04

1005.3 Component Description: 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 sixteen or twenty-four 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 sixteen or twenty-four 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 twenty-four inch centers for both walls.

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

2 x 4 Single Wood Stud: R-11 Batt

R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood ADV	T1-11 STD	T1-11 ADV
0	.088	.084	.094	.090
1	.080	.077	.085	.082
2	.074	.071	.078	.075
3	.069	.066	.072	.070
4	.064	.062	.067	.065
5	.060	.058	.063	.061
6	.056	.055	.059	.057
7	.053	.052	.055	.054
8	.051	.049	.052	.051
9	.048	.047	.050	.049
10	.046	.045	.047	.046
11	.044	.043	.045	.044
12	.042	.041	.043	.042

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

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

2 x 4 Single Wood Stud: R-13 Batt

R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood ADV	T1-11 STD	T1-11 ADV
0	.082	.078	.088	.083
1	.075	.072	.080	.076
2	.069	.066	.073	.070
3	.065	.062	.068	.065
4	.060	.058	.063	.061
5	.057	.055	.059	.057
6	.053	.052	.056	.054
7	.051	.049	.052	.051
8	.048	.047	.050	.048
9	.046	.045	.047	.046
10	.044	.043	.045	.044
11	.042	.041	.043	.042
12	.040	.039	.041	.040

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

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

2 x 4 Single Wood Stud: R-15 Batt

R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood ADV	T1-11 STD	T1-11 ADV
0	.076	.071	.081	.075
1	.069	.065	.073	.069
2	.064	.061	.068	.069
3	.060	.057	.063	.059
4	.056	.053	.059	.056
5	.053	.051	.055	.052
6	.050	.048	.052	.050
7	.047	.046	.049	.047
8	.045	.044	.047	.045
9	.043	.042	.044	.043
10	.041	.040	.042	.041
11	.039	.038	.041	.039
12	.038	.037	.039	.038

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

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

2 x 6 Single Wood Stud: R-19 Batt

R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood INT	Lapped Wood ADV	T1-11 STD	T1-11 INT	T1-11 ADV
0	.062	.058	.055	.065	.061	.058
1	.058	.055	.052	.060	.057	.055
2	.054	.052	.050	.056	.054	.051
3	.051	.049	.047	.053	.051	.049
4	.048	.046	.045	.050	.048	.046
5	.046	.044	.043	.048	.046	.044
6	.044	.042	.041	.045	.044	.042
7	.042	.040	.039	.043	.042	.040
8	.040	.039	.038	.041	.040	.039
9	.038	.037	.035	.039	.038	.037
10	.037	.036	.035	.038	.037	.036
11	.036	.035	.034	.036	.035	.035
12	.034	.033	.033	.035	.034	.033

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

Installed Batt R-Value
R-18 in 5.5-inch cavity

2 x 6 Single Wood Stud: R-21 Batt

	R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood INT	Lapped Wood ADV	T1-11 STD	T1-11 INT	T1-11 ADV
NOTE:							
Nominal BATT R-value .053	0	.057	.054	.051	.060	.056	
R-21 at 5.5-inch thickness							
	1	.054	.051	.048	.056	.053	.050
Installed Batt R-value	2	.050	.048	.045	.052	.050	.047
R-21 in 5.5-inch cavity	3	.048	.045	.043	.049	.047	.045
	4	.045	.043	.041	.047	.045	.043
	5	.043	.041	.040	.044	.042	.041
	6	.041	.039	.038	.042	.041	.039
	7	.039	.038	.036	.040	.039	.037
	8	.038	.036	.035	.039	.037	.036
	9	.036	.035	.034	.037	.036	.035
	10	.035	.034	.033	.036	.035	.033
	11	.033	.033	.032	.034	.033	.032
	12	.032	.031	.031	.033	.032	.031

2 x 6 Single Wood Stud: R-22 Batt

	R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood INT	Lapped Wood ADV	T1-11 STD	T1-11 INT	T1-11 ADV
NOTE:							
Nominal Batt R-value	0	.059	.055	.052	.062	.058	.054
R-22 at 6.75-inch thickness							
	1	.055	.052	.049	.057	.054	.051
Installed Batt R-value	2	.052	.049	.047	.054	.051	.048
R-20 in 5.5-inch cavity	3	.049	.046	.044	.050	.048	.046
	4	.046	.044	.042	.048	.046	.044
	5	.044	.042	.041	.045	.043	.042
	6	.042	.040	.039	.043	.042	.040
	7	.040	.039	.037	.041	.040	.038
	8	.038	.037	.036	.039	.038	.037
	9	.037	.036	.035	.038	.037	.035
	10	.035	.034	.033	.036	.035	.034
	11	.034	.033	.032	.035	.034	.033
	12	.033	.032	.031	.034	.033	.032

2 x 6 Single Wood Stud: Two R-11 Batts

	R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood INT	Lapped Wood ADV	T1-11 STD	T1-11 INT	T1-11 ADV
NOTE:							
Nominal Batt R-value	0	.060	.057	.054	.063	.059	.056
R-22 at 7-inch thickness							
	1	.056	.053	.051	.059	.056	.053
Installed Batt R-value	2	.053	.050	.048	.055	.052	.050
R-18.9 in 5.5-inch cavity	3	.050	.048	.046	.052	.049	.047
	4	.047	.045	.044	.049	.047	.045
	5	.045	.043	.042	.046	.045	.043
	6	.043	.041	.040	.044	.043	.041
	7	.041	.040	.038	.042	.041	.039
	8	.039	.038	.037	.040	.039	.038
	9	.038	.037	.036	.039	.038	.036
	10	.036	.035	.034	.037	.036	.035
	11	.035	.034	.033	.036	.035	.034
	12	.034	.033	.032	.034	.034	.033

2 x 8 Single Stud: R-25 Batt

	R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood INT	Lapped Wood ADV	T1-11 STD	T1-11 INT	T1-11 ADV
NOTE:							
Nominal Batt R-value	0	.051	.047	.045	.053	.049	.046
R-25 at 8-inch thickness							
	1	.048	.045	.043	.049	.046	.044
Installed Batt R-value	2	.045	.043	.041	.047	.044	.042
R-23.6 in 7.25-inch cavity	3	.043	.041	.039	.044	.042	.040
	4	.041	.039	.037	.042	.040	.038
	5	.039	.037	.036	.040	.038	.037
	6	.037	.036	.035	.038	.037	.036
	7	.036	.035	.033	.037	.035	.034
	8	.035	.033	.032	.035	.034	.033
	9	.033	.032	.031	.034	.033	.032
	10	.032	.031	.030	.033	.032	.031
	11	.031	.030	.029	.032	.031	.030
	12	.030	.029	.028	.031	.030	.029

2 x 6: Strap Wall

	Siding Material/Frame Type			
	Lapped Wood		T1-11	
	STD	ADV	STD	ADV
R-19 + R-11 Batts	.036	.035	.038	.036
R-19 + R-8 Batts	.041	.039	.042	.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	.040	.037	.041	.038
R-19	------	R-19	.034	.031	.035	.032
R-19	R-8	R-11	.029	.028	.031	.029
R-19	R-11	R-11	.027	.026	.028	.027
R-19	R-11	R-19	.024	.023	.025	.023
R-19	R-19	R-19	.021	.020	.021	.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	.050	.046	.052	.048
R-19	------	R-11	.039	.037	.043	.039
R-11	R-8	R-11	.037	.035	.036	.036
R-11	R-11	R-11	.032	.031	.033	.032
R-13	R-13	R-13	.029	.028	.029	.028
R-11	R-19	R-11	.026	.026	.027	.026

Log Walls

NOTE:	Average Log Diameter	U-value
R-value of wood:	6-inch	0.148
R-1.25 per inch thickness	8-inch	0.111
Average wall thickness	10-inch	0.089
90% average log diameter	12-inch	0.074
	14-inch	0.063
	16-inch	0.056

Stress Skin Panel

NOTE:	Panel Thickness	U-value
R-value of	3 1/2-inch	.071
expanded polystyrene:	5 1/2-inch	.048
R-3.85/inch	7 1/4-inch	.037
	9 1/4-inch	.030
Framing: 6%	11 1/4-inch	.025
Spline: 8%		
No thermal bridging between interior and exterior splines		

Single Metal Stud

Nominal Wall Thickness	Nominal Insulation R-Value	Effective Insulation R-Value	Stud Spacing 16" O.C.	Stud Spacing 24" O.C.
4 inch	R-11	R-11	.14	.13
4 inch	R-13	R-12.7	.13	.12
6 inch	R-19	R-18	.11	.10

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

1006.1 Untested Glazing and Doors: Untested glazing and doors shall be assigned the following U-values:

a. Manufactured glazing products:

single glazing (all):	U = 1.20;
double glazing:	
aluminum or steel framed:	U = 0.90;
wood or vinyl framed:	U = 0.75;

b. Non-manufactured site built fixed lite glazing products with a minimum of one-half inch airspace in a wood frame only. All products supplied by manufacturers, such as kits for solariums, shall use the default U-values for manufactured glazing products cited above.

air-filled:	U = 0.60;
argon-filled:	U = 0.55;
low-e, air-filled:	U = 0.50;
low-e, argon-filled:	U = 0.40;

Products which do not comply with all of these criteria shall use the default U-values listed under manufactured glazing products.

c. For doors, see Table 10-6 on the next page.

TABLE 10-6 TRANSMISSION COEFFICIENTS (U) FOR WOOD AND STEEL DOORS
Btu/hr•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 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 w/ 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 w/ 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 percent glass area.
[d] Values for metal storm door are for any percent glass area.
[e] 55 percent 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 6 are for exterior wood and steel doors. The values given for wood doors were calculated, and those for steel doors were taken from hot box 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, the glazing should be analyzed as a window.

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/°F•hr•ft² of ceiling.

They are derived from procedures listed in RS-1, listed in Chapter 7. Ceiling U-values 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 Hr•°F•ft²/BTU per inch. Full bag count for specified R-value is assumed in all cases. Ceiling dimensions for flat ceiling calculations are forty-five by thirty feet, with a gabled roof having a 4/12 pitch. The attic is assumed to vent naturally at the rate of three 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-values for flat ceilings below vented attics with standard framing may be modified with the following table:

	U-Value for Standard Framing	
Roof Pitch	**R-30**	**R-38**
4/12	.036	.031
5/12	.035	.030
6/12	.034	.029
7/12	.034	.029
8/12	.034	.028
9/12	.034	.028
10/12	.033	.028
11/12	.033	.027
12/12	.033	.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 three 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.

TABLE 10-7
DEFAULT U-VALUES 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

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/hr•°F
2	2000	0.0168 Btu/hr•°F
3	3000	0.0162 Btu/hr•°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 RS-1, Chapter 22.

Thermal capacity of furniture is ignored, as is heat storage beyond the first four 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:

$$\text{Ln(R-value)} \times (-.221) + 0.5$$

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/°F•ft² 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 trompe walls, and extra layers of sheetrock. Coefficients are in Btu/°F•ft² of surface area of material exposed to conditioned space. The coefficient for water is Btu/°F-gallon.

1009.3 Component Description: Light frame assumes one inch thick wood flooring with five-eights inch sheetrock on ceilings and interior walls, and walls consisting of either five-eights inch sheetrock or solid logs. Slab assumes a four inch concrete slab on or below grade, with five-eights 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/°F•Ft² 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/°F•Ft² surface area
Gypsum wallboard, 1/2-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