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1986 WASHINGTON STATE ENERGY CODE

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Washington state energy code, chapter 51-12 WAC 1986.

PREFACE

This document is a reproduction of the Washington State Energy Code, Chapter 51-12 WAC. The official copy of Chapter 51-12 WAC is on file with the Washington State Code Reviser, Legislative Building, AS-15, Olympia, Washington 98504. In transcribing this copy of the Washington State Energy Code, care has been taken to insure that a true and correct copy has been published. However, if an error occurs between Chapter 51-12 WAC on file with the Washington State Code Reviser and this publication, the official document on file will govern.

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1986
WASHINGTON STATE ENERGY CODE
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Chapter 1
ADMINISTRATION AND ENFORCEMENT
SCOPE AND GENERAL REQUIREMENTS

100. TITLE.

This Code shall be known as the "State Energy Code" and may be cited as such; and will be referred to herein as "this Code."

101. 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 of energy.

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

Compliance with any one of these paths 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.

102. 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 effective use of energy.

Buildings shall be designed to comply with the requirements of either Chapter 4, 5, or 6 of this Code.

(a) **Exempt Buildings.** Buildings and structures or portions thereof meeting any of the following criteria shall be exempt from the building envelope requirements of Sections 402 to 405 inclusive, and Sections 601 and 605, but shall comply with all other requirements for building mechanical systems, service water heating and lighting systems.

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 all purposes.

2. Buildings and structures or portions thereof which are neither heated nor cooled by a depletable energy source, including buildings heated with wood with installed backup or supplemental heating utilizing a depletable energy source provided that: the depletable energy use complies with the requirements of exemption (1).

(b) **Application to Existing Buildings.**

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.

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.

(c) **Alterations and Repairs.** Initial tenant alterations shall comply with the new construction requirements of this Code. Other alterations and repairs may be made to existing buildings without making the entire building comply with all of the requirements of this Code for new buildings, provided the following requirements are met:

1. **Building Envelope.** The result of the alterations or repairs (1) improves the energy efficiency of the building and (2) complies with the overall average thermal transmittance values of the gross area of the elements of the exterior building envelope in Table 4-2, 4-3, or 4-4 of Chapter 4 or the nominal R values in Tables 6-1 or 6-5 and U values in Table 6-2 or glazing requirements in Table 6-5 of Chapter 6. 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 roof/ceilings, walls and floors without framing cavities need not be insulated.

2. **Building Mechanical Systems.** Those parts of systems which are altered or replaced shall comply with this Code. Heating equipment efficiencies for low-rise residential occupancy buildings shall comply with the minimum efficiency requirements of Table 6-4.

3. **Service Water Heating.** Those parts of systems which are altered or replaced shall comply with Section 420.

4. **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 425. Other remodels or replacements of lighting systems which are part of a substantial remodel shall comply with Section 425. In addition, other remodels or replacements which affect the lighting system of an entire floor shall comply with the lighting power budgets specified in Table No. 4-18.

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 his/her opinion full conformance 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.

103. CONFLICTS WITH OTHER CODES.

In addition to the requirements of this Code, buildings must conform to the provisions included in the State Building Code (Chapter 19.27 RCW and Chapter 51-16 WAC). In case of conflicts between the Codes listed in Chapter 51-16 WAC and this Code, the provisions of the Codes listed in Chapter 51-16 WAC shall govern. Provided, in the case of conflict between the ventilation requirements of this Code and ventilation requirements of Sections 605, 705, 905 and 1205 of the Uniform Building Code, and the duct insulation requirements of this Code and the duct insulation requirements of Section 1005 of the Uniform Mechanical Code, the ventilation and duct insulation requirements of this Code, or where applicable, a local jurisdiction's energy code shall govern.

104. MATERIALS AND EQUIPMENT.

(a) **Identification.** All materials and equipment shall be identified in order to show compliance with this Code.

(b) **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.

105. 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 the Code.

The Building Official may require that sufficient evidence or proof be submitted to substantiate any claims that may be made regarding performance capabilities.

106. PLANS AND SPECIFICATIONS.

(a) **General.** When required by the Building Official, plans and specifications shall be submitted with each application for a building permit. The Building Official may require plans and specifications be prepared by an engineer or architect licensed to practice by the state. All energy calculations submitted under the provisions of Chapter 5 for other than low-rise residential occupancy buildings shall be prepared 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.

(b) **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 conformance with the requirements of this Code.

(c) The Building Official may accept the professional stamp of an architect or engineer licensed to do business in 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.

107. INSPECTIONS AND ENFORCEMENT.

(a) **General.** All construction or work for which a permit is required shall be subject to inspection by the Building Official.

(b) **Authority.** Local legislative authorities are authorized and directed to enforce this Code. Local legislative authorities are authorized to promulgate, adopt, and issue those rules and regulations necessary to the effective and efficient administration of this Code.

(c) **Inspections.** All buildings constructed under the provisions of this Code are subject to a final inspection for compliance with this Code. The Building Official has the authority to establish procedures for accepting substantial compliance with this Code in lieu of a final inspection.

108. 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.

109. 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.

EXCEPTION: As provided in Section 3, Chapter 144, Laws of 1985, a city, town or county may adopt an alternative energy code if the conditions set forth in the statute are met. If a less energy efficient alternate energy code is adopted on the basis that this Code is not cost-effective, the city, town, or county shall submit documentation of the relative cost-effectiveness to the State Building Code Council for review and comment prior to adoption.

110. LIABILITY.

Nothing contained in this Code is intended to be nor shall be construed to create or form the basis for any liability on the part of any city or county or its officers, employees or agents' for any injury or damage resulting from the failure of a building to conform to the provisions of this Code.

Chapter 2
DEFINITIONS

200. GENERAL.

For the purpose of this Code, certain abbreviations, terms, phrases, words and their derivatives shall be construed as specified in this section. Words used in the singular include the plural and the plural the singular. Words used in the masculine gender include the feminine and the feminine the masculine.

201. A.

ACCESSIBLE (as applied to Equipment). Allowing close approach, not guarded by locked doors, elevation or other effective means. (See READILY ACCESSIBLE.)

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

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

ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE). The amount of energy delivered to the dwelling in the form of useable heat, as a percentage of the total energy input of the fuel consumed. AFUE refers to a performance rating required under the provision of the National Energy Policy and Conservation Act (NECPA), Pub. L95-619. AFUE's taken from the "Energy Guide" published by the Gas Appliance Manufacturers' Association (GAMA) meet this definition. AFUE's apply to all central residential sized furnaces (inputs of less than 225,000 Btu/h).

ASHRAE. American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc.

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.

202. B.

BOILER CAPACITY. The rate of heat output in Btu/h measured at the boiler outlet at the design pressure and/or temperature and rated fuel input.

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

BUILDING OFFICIAL. The officer or other designated authority charged with the administration and enforcement of this Code, or his duly authorized representative.

203. C.

CLERESTORY. A window placed high in a wall or projecting from a roof plane, to admit daylight into the interior of a building.

COEFFICIENT OF PERFORMANCE (COP). See Section 411 for various definitions of COP.

CONDITIONED SPACE. Any horizontal or vertical projection or any combination of that portion of interior space which is contained within exterior walls and which is heated or cooled directly or indirectly by an energy-using system.

204. D.

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

DEPLETABLE ENERGY SOURCES. (See ENERGY SOURCES.)

205. E.

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

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; in customary units, measured in kilowatt-hours (kWh) or British thermal units (Btu).

ENERGY EFFICIENCY RATIO (EER). The ratio of net cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions. When International System of units are used this becomes equal to COP. (See COP.)

ENERGY SOURCES. Nondepletable energy sources are sources of energy (excluding minerals) derived from: (1) incoming solar radiation, including, but not limited to, natural daylighting and photosynthetic processes, (2) energy sources resulting from wind, waves and tides, lake or pond thermal differences; and (3) energy derived from the internal heat of the earth, including nocturnal thermal exchanges. Depletable energy sources are all other sources including natural gas, oil, coal, liquified petroleum gas, and any utility-supplied electricity. Wood is a nondepletable energy source within the limitations of Section 102 (a)2.

ENERGY, NEW. (See NEW ENERGY.)

ENERGY, RECOVERED. (See RECOVERED ENERGY.)

EXFILTRATION. The uncontrolled outward air leakage through cracks and interstices in any building element such as around soleplates, wall outlets, duct systems, 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.

EXTERIOR ENVELOPE. (See BUILDING ENVELOPE.)

206. F. (RESERVED.)

207. G.

GENERAL LIGHTING. Lighting designed to provide an approximately uniform level of illumination in an area.

GLAZING AREA. Total area of glazing measured using the rough opening and including the glass, the sash, and the frame.

GROSS FLOOR AREA. The sum of the areas of the floors of the building, including basements, mezzanine and intermediate-floored tiers and penthouses of headroom height, measured from the exterior faces of exterior walls or from the centerline of walls separating buildings: PROVIDED, That:

Covered walkways, open roofed-over areas, porches and similar spaces and features such as pipe trenches, exterior terraces or steps, chimneys, roof overhangs, etc., shall be excluded.

GROSS WALL AREA. The vertical projection of the exterior wall area bounding interior space which is conditioned by an energy-using system; includes opaque wall, window, clerestory, and door areas. The gross area of exterior walls consists of all opaque wall areas, including fully insulated foundation walls above and below grade, between floor spandrels, peripheral edges of floors, window areas, including sash, and door areas, where such surfaces are exposed to outdoor air and enclose a heated or mechanically cooled space including interstitial areas between two such spaces.

208. H.

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

HEAT STORAGE CAPACITY. The ability of mass to absorb heat during overheated periods and store it for release during underheated periods, as calculated in Sec. 402 (d)6.

HEATED SLAB. A slab on grade containing heated pipes, ducts, or electric heating cables that constitute a radiant slab or portion thereof for complete or partial heating of the structure.

HEATED SPACE. Space, within a building, which is provided with a positive heat supply to maintain air temperature of 50°F (10°C) or higher.

HEATING SEASON PERFORMANCE FACTOR (HSPF). 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. When specified in BTU output per watt hour input, an HSPF of 6.826 is equivalent to an HSPF of 2.0 watt hour output per watt hour input.

HUMIDISTAT. An instrument which measures changes in humidity and controls a device(s) for maintaining a desired humidity.

HVAC. Heating, ventilating and air conditioning.

HVAC SYSTEM. A system that provides either collectively or individually the processes of comfort heating, ventilating, and/or air conditioning within or associated with a building.

209. I.

INFILTRATION. The uncontrolled inward air leakage through cracks and interstices in any building element and around soleplates, wall outlets, duct systems, 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.

210. J. (RESERVED.)

211. K. (RESERVED.)

212. L.

LOW-RISE RESIDENTIAL. Single and multifamily occupancy (R-3 and R-1) in buildings three stories or less.

213. M.

MANUAL. Capable of being operated by personal intervention.

214. N.

NEW ENERGY. Energy, other than recovered energy, utilized for the purpose of heating or cooling.

NONDEPLETABLE ENERGY SOURCES. (See ENERGY SOURCES.)

215. O.

OCCUPANCY. See UBC definition.

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

OUTSIDE AIR. Air taken from the outdoors and, therefore, not previously circulated through the HVAC system of a building or structure.

OVERALL SYSTEM EFFICIENCY. (See EFFICIENCY, OVERALL SYSTEM.)

216. P.

PACKAGED TERMINAL AIR-CONDITIONER. A factory-assembled combination of heating and cooling components, assemblies or sections, intended to serve a room or a zone.

PASSIVE COOLING. Cooling, humidification, and/or dehumidification of a conditioned space using minimal mechanical assistance.

PERM. A measurement of water vapor permeability for a particular material with a specific thickness. One perm equals the transfer of one grain of water vapor through one square foot of material in one hour with a one inch mercury vapor pressure difference from one side of the material to the other.

PERMEABILITY. Water vapor permeability is a measure of the passage of water vapor through a substance. When permeability varies with psychrometric conditions, the "spot" or "specific permeability" defines the property at a specific condition. Permeability is measured in perm inches.

POSITIVE HEAT SUPPLY. Heat supplied to a space by design or by heat losses occurring from energy-consuming systems or components associated with that space.

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).

217. Q. (RESERVED.)

218. R.

READILY ACCESSIBLE. Capable of being reach quickly for operation renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See ACCESSIBLE.)

RECOMMEND. Suggest as appropriate; not required.

RECOVERED ENERGY. Energy utilized which would otherwise be wasted from an energy utilization system.

REGISTERED ENGINEER. A professional engineer licensed to practice in the State of Washington and knowledgeable and skilled in the use of the methods and practices associated with the specific engineering discipline being practiced.

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.

RESTAURANT. A building or portion of a building principally used for the retail preparation and service of food or beverages.

ROOF ELEMENT. A roof element shall be considered as a component of the roof/ceiling envelope, excluding clerestories, through which heat flows, thereby creating a building transmission heat loss or gain, where such assembly is exposed to outdoor air and encloses a heated or mechanically cooled space.

ROOF ELEMENT, GROSS AREA OF. The gross area of a roof element consists of the total interior surface of such element, including skylights, excluding clerestories, exposed to the heated or mechanically cooled space.

ROOM AIR CONDITIONER. An encased assembly designed as a unit primarily for mounting in a window or through a wall, or as a console. It is designed primarily 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 include means for ventilating and heating.

219. S.

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. External protection of glazing area from direct solar radiation by use of devices permanently affixed to the structure or by an adjacent building, topographical feature or vegetation.

SHALL. Where shall is used in specific provision, that provision is mandatory.

SHOULD. Not mandatory but desirable as good practice.

SKYLIGHT. A clear or translucent panel or slope set in the plane of a roof to admit daylight into the interior of a building.

SLAB ON GRADE (in a heated space). Any portion of a slab poured in contact with the ground where the top of the finished slab is less than 12 inches below the final elevation of the nearest exterior grade.

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

SUBSTANTIALLY REMODELED OR REHABILITATED. Any alteration or restoration of a building or structure within any 12 month period, the cost of which exceeds 60 percent of the current replacement value of the particular building or structure.

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

220. T.

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

THERMAL RESISTANCE (R). The resistance of a material to heat flow, measured as the inverse of heat flow per unit area, per unit time, per unit temperature difference across the thickness of material considered. In this Code, R has units of sq. ft. hr. °F/Btu.

THERMAL TRANSMITTANCE (U). Overall coefficient of heat transmission (air to air) expressed in units of Btu per hour per square foot per degree F. It is the time rate of heat flow. The U value applies to combinations of different materials used in series along the heat flow path, single materials that comprise a building section, cavity air spaces, and surface air films on both sides of a building element.

THERMAL TRANSMITTANCE (U_0). Overall (average) heat transmission of a gross area of the exterior building envelope, expressed in units of Btu per hour, per degree F per square foot of exterior building envelope.

The U_0 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 instrument which measures changes in temperature and controls device(s) for maintaining a desired temperature.

221. U.

U VALUE. See **THERMAL TRANSMITTANCE.**

UNIFORM BUILDING CODE. Regulations promulgated by the International Conference of Building Officials and covering the fire, life and structural safety aspects of all buildings and related structures.

UNIFORM MECHANICAL CODE. Regulations promulgated by the International Conference of Building Officials and containing requirements for the installations and maintenance of heating, ventilation, cooling and refrigeration systems.

UNITARY COOLING AND HEATING EQUIPMENT. One or more factory-made assemblies which may 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 normally 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. It is designed to provide the functions of air-circulating, air cleaning, cooling and heating with controlled temperature, and dehumidifying, and may optionally include the function of humidifying. When such equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

222. V.

VAPOR BARRIER. See VAPOR RETARDER.

VAPOR RETARDER. A vapor retarder is a material, or a system of components within a building element, which restricts the transfer of water vapor from one side of the retarder to the other side with a rating of 1.0 perm dry cup rating or less.

223. W X Y Z.

WINDOW THERMAL TESTING. U values for Class 75 or Class 60 glazing shall be the tested values for thermal transmittance due to conduction resulting from either the American Architectural Manufacturers Association (AAMA) 1503.1-1980 test procedure or the American Society for Testing Materials (ASTM) C236 or C976 test procedures; testing shall be conducted under established winter horizontal heat flow test conditions using the 15 mph wind speed and product sample sizes specified under AAMA 1503.1-1980. Testing shall be conducted by a certified testing laboratory. Sealed insulating glass, where used, shall conform to ASTM E-774-81 level C or better.

EXCEPTION: U values for site built fixed lites shall use window thermal test results when available. If tested results are unavailable, the Building Official shall require documentation based on a tested value of a comparable window.

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.

Chapter 3
DESIGN REQUIREMENTS

300. GENERAL.

This Chapter establishes design criteria in terms of the thermal performance of the various components of a building.

301. HEATED AND COOLED BUILDINGS.

A building designed to be both heated and cooled shall meet the more stringent of the heating or cooling requirements provided in this Code.

302. CLIMATIC ZONES.

Climatic Zones are based on heating degree days; therefore, some local deviation may be necessary to reflect actual conditions. Some counties have cities/towns which are both above and below 6,000 Degree Day, Heating (DDH). They have been placed in their respective zones on the basis of average DDH as derived by weighing DDH by each town's 1980 population.

The following shall be used for calculations and prescriptions required under this Code.

(a) Zone I consists of the following counties: Asotin, Benton, Chelan, Clallam, Clark, Columbia, Cowlitz, Douglas, Franklin, Garfield, Grays Harbor, Island, Jefferson, King, Kitsap, Klickitat, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston, Walla Walla, Wahkiakum, Whatcom, Yakima.

(b) Zone II consists of the following counties: Adams, Ferry, Grant, Kittitas, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens, Whitman.

EXCEPTION: The local jurisdiction may authorize an alternate zone for application of energy code requirements in areas where heating degree days are above 6,000 in Zone I and 6,000 heating degree days or below in Zone II. The adoption of a specific climatic zone shall be designated as part of the Ordinance adopted by the local governing body.

303. DEPARTURES.

Departure from the criteria of this chapter is permitted if the substitute data is documented and presented to the Building Official for his/her concurrence.

304. DESIGN PARAMETERS.

The following design parameters shall be used for calculations required under this Code.

(a) Indoor design temperature shall be 70°F for heating and 78°F for cooling.

(b) Indoor design relative humidity for heating shall not exceed 30 percent.

(c) 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.)

305. VENTILATION.

The outdoor air quantities specified in Table 3-1 for each type of occupancy shall be used as a minimum for design. These quantities are for 100 percent outdoor air ventilating systems, but a reduction to 33 percent of the specified values for recirculating HVAC systems is permitted. In no case, shall the outdoor air quantities be less than 5 CFM per person.

The minimum requirements for openable area to provide natural ventilation are specifie in the 1985 Uniform Building Code as adopted by the State of Washington. All kitchens and bathrooms without natural ventilation in Group R Occupancy spaces shall be provided with exhaust fans or other ventilation systems approved by the building official having a capacity of not less than that specified in Table No. 3-1. (See UBC Section 1205.) Ventilation requirements for other occupancy spaces may be met using operable openings as provided in the UBC.

Where a mechanical ventilation system is installed, the mechanical ventilation system shall be capable of supplying to each zone ventilation air with the minimum outdoor air quantities specified in Table No. 3-1 based upon the greater of the occupant densities in that table or the design occupant density. The outdoor air shall be ducted directly to very air handling unit in each zone not provided with sufficient openable area for natural ventilation. The maximum outdoor air quantities used as the basis for calculating the heating and cooling design loads shall not exceed three times the quantities specified in Table No. 3-1.

EXCEPTION: If outdoor air quantities other than those specified in Table No. 3-1 are used or required because of special occupancy or process requirements, source control of air contamination, health, and safety or other standads, the required outdoor air quantities shall be used as the basis for calculating the heating and cooling design loads.

Table No. 3-1 is an excerpt from ASHRAE Standard 62-73, "Natural and Mechanical Ventilation" published in 1973. Standard 62-73 is no longer in print. ASHRAE now recommends the use of Standard 62-81 "Ventilation for acceptable Indoor Air Quality" for improved ventilation design.

TABLE NO. 3-1
AIR QUANTITIES FOR VENTILATION[1]

	Estimated Occupancy, persons per 1000 ft^2. Use only when design occupancy is not known	Outdoor Air Requirements
RESIDENTIAL (Private dwelling places, single or multiple units)		
		cfm/person
Single Unit Dwellings		
General living areas, bedrooms	5	5
Kitchens[2]	-	20
Baths, toilet rooms[2]	-	20
Basements, utility rooms	-	5
Multiple Unit Dwellings		
General living areas, bedrooms	7	5
Kitchens[2]	-	20
Baths, toilet rooms[2]	-	20
Basements, utility rooms	-	5
		cfm/ft^2 floor
Garages	-	1.5
		cfm/person
Mobile Homes	7	5
COMMERCIAL		
		cfm/person
Ballrooms		
Public	100	15
Banks		
Vaults	-	5
Barber, Beauty and Health Services		
Beauty shops (hair dressers)	50	25
Reducing salons (exercise rooms)	20	25
Sauna baths and steam rooms	-	5
Barber shops	25	7
Bowling Alleys		
Seating area	70	15
Communication		
TV/radio broadcasting booths, radio studios[8]	20	30
Motion picture and TV stages	20	30
Pressrooms	100	15
Composing rooms	30	7
Engraving shops	30	7
Telephone switchboard rooms (manual)	50	7
Telephone switchgear rooms (automatic)	-	7
Teletypewriter/facsimile rooms	-	5

TABLE NO. 3-1 (cont.)
AIR QUANTITIES FOR VENTILATION[1]

	Estimated Occupancy, persons per 1000 ft^2. Use only when design occupancy is not known	Outdoor Air Requirements
	COMMERCIAL	cfm/person
Dry Cleaners and Laundries		
Commercial[6,7]	10	20
Storage/pickup areas	30	7
Coin-operated[7]	20	15
Drug Stores		
Pharmacists' work rooms	10	20
Food Markets, Supermarkets, etc.		
Meat processing rooms[3]	10	5
Food Services		
Dining Rooms	70	10
Kitchens[6]	20	30
Cafeterias, short-order, drive-ins, seating areas, and queuing areas	100	30
Bars (predominantly stand-up)	150	30
Cocktail lounges	100	30
Garages, Auto Repair Shops, Service Stations		cfm/ft^2 floor
Parking garages (enclosed)	-	1.5
Auto repair workrooms (general)[9]	-	1.5
		cfm/person
Service station offices	20	7
Gymnasiums and Arenas		
Playing floors - minimal or no seating	70	20
		cfm/locker
Locker rooms	20	30
		cfm/person
Spectator areas	150	20
Ramps, foyers and lobbies	150	10
Hotels, Motels, Resorts		
Bedrooms (single, double)	5	7
Living rooms (suites)	20	10
Baths, toilets (attached to bedrooms)[2]	-	20
Corridors	5	5
Lobbies	30	7
Conference rooms (small)	70	20
Assembly rooms (large)	140	15
Public rest rooms	100	15
Cottages (treat as single-unit dwellings)	-	-
Ice-skating and Curling Rinks[11]	70	10

TABLE NO. 3-1 (cont.)
AIR QUANTITIES FOR VENTILATION[1]

	Estimated Occupancy, persons per 1000 ft^2. Use only when design occupancy is not known	Outdoor Air Requirements
	COMMERCIAL	
		cfm/person
Merchandising		
Sales floors and showrooms (basement and street floors)	30	7
Sales floors and showrooms (upper floors)	20	7
Storage areas (serving sales floors and storerooms)	5	5
Dressing rooms	-	7
Malls and arcades	40	7
Shipping and receiving areas	10	15
Warehouses	5	7
Offices		
General office space	10	15
Conference rooms	60	25
Drafting rooms, art rooms	20	7
Doctor's consultation rooms	-	10
Waiting rooms (doctors, employment agencies, etc.)[7]	30	10
Lithographing rooms[7]	20	7
Diazo printing rooms	20	7
Computer rooms	20	5
Keypunching rooms	30	7
Public rest rooms	100	15
Photo Studios		
Camera rooms, stages[8]	10	5
Darkrooms	10	10
Pool Rooms	25	20
Roller Rinks[11]	70	10
Shoe Repair Shops	10	10
Specialty Shops		cfm/ft^2 floor
Pet shops	-	1.0
		cfm/person
Florists[4]	10	5
Greenhouses[4,5]	1	5
Swimming Pools (indoor)[11]	25	15
Tennis, Squash, Handball Courts (indoor)	-	20

TABLE NO. 3-1 (cont.)
AIR QUANTITIES FOR VENTILATION[1]

	Estimated Occupancy, persons per 1000 ft^2. Use only when design occupancy is not known	Outdoor Air Requirements
	COMMERCIAL	
		cfm/person
Theatres		
Ticket booths	-	5
Lobbies (foyers and lounges)	150	20
Auditoriums (in motion picture theatres, legitimate theatres, lecture, concert and opera halls - no smoking)	150	5
Auditoriums (smoking permitted)	150	10
Stages (with proscenium and curtains)[8,10]	70	10
Green rooms and workrooms	20	10
Public rest rooms	100	15
Transportation		
Waiting rooms	50	15
		cfm/ft^2 floor
Garages	-	1.5
Ticket and baggage areas,		cfm/person
corridors and gate areas	50	15
Control towers	50	25
Hangers[12]	2	10
Public rest rooms	100	15
Platform	150	10
Concourses	150	10
Repair shops	-	10
	INSTITUTIONAL	
		cfm/person
Hospitals, Nursing and Convalescent Homes		
Foyers	50	20
Hallways	50	20
Single, dual bedrooms	15	10
Wards	20	10
Food service centers	20	35
Operating rooms, delivery rooms[14]	-	20
Ready rooms, recovery rooms[14]	-	15
Amphitheatres	100	10
Physical therapy areas	20	15
Autopsy rooms	10	30
Incinerator service areas[15]	-	5
Military and Naval Installations		
Barracks	20	7
Toilets/washrooms	100	15
Shower rooms	100	10
Drill halls	70	15
Ready rooms, MP stations	40	7
Indoor target ranges[16]	70	20
Museums		
Exhibit halls	70	7
Workrooms	10	10
Warehouses	5	5

TABLE NO. 3-1 (cont.)
AIR QUANTITIES FOR VENTILATION[1]

	Estimated Occupancy, persons per 1000 ft^2. Use only when design occupancy is not known	Outdoor Air Requirements
INSTITUTIONAL		
		cfm/person
Prisons		
Cell blocks	20	7
Eating halls	70	15
Guard stations	40	7
Research Institutes		
Laboratories (light-duty, nonchemical)[13]	50	15
Laboratories (chemical)[13]	50	15
Laboratories (heavy-duty)[13]	50	15
Laboratories (radioisotope, chemically and biologically toxic)[13]	50	15
Machine shops	50	15
Darkrooms, spectroscopy rooms	50	10
Animal rooms[15]	20	40
Schools		
Classrooms	50	10
Multiple use rooms	70	10
Laboratories[13]	30	10
Craft shops, vocational training shops[13]	30	10
Music, rehearsal rooms	70	10
Auditoriums	150	5
Gymnasiums	70	20
Libraries	20	7
Common rooms, lounges	70	10
Offices	10	7
Lavatories	100	15 cfm/locker
Locker rooms	20	30 cfm/person
Lunchrooms, dining halls	100	10
Corridors	50	15
Utility rooms	3	5
Dormitory bedrooms	20	7
Veterinary Hospitals		
Kennels, stalls[14]	20	25
Operating rooms[14]	20	25
Reception rooms	30	10

TABLE NO. 3-1 (cont.)
AIR QUANTITIES FOR VENTILATION[1]

	Estimated Occupancy, persons per 1000 ft^2. Use only when design occupancy is not known	Outdoor Air Requirements
	ORGANIZATIONAL	cfm/person
Churches, Temples (See Theaters, Schools and Offices)	-	-
Legislative Halls		
Legislative chambers	70	20
Committee rooms and conference rooms	70	20
Foyers, corridors	50	20
Offices	10	10
Press lounges	20	20
Press/radio/TV booths	20	20
Public rest rooms	20	15
Private rest rooms	-	20
Police and Fire Stations (See Prisons and Military Installations)	-	-
Survival Shelters[14]	-	5

1. Derived from ASHRAE Standard 62-73, alphabetized for ease of use.
2. Independent of room size; installed capacity for intermittent use.
3. Spaces maintained at low temperatures (-10°F. to +50°F.) are not covered by these requirements unless the occupancy is continuous. Ventilation from adjoining spaces is permissible. When the occupancy is intermittent, infiltration will normally exceed the ventilation requirement.
4. Maximum allowable concentration (MAC) for sulfur dioxide = 30 micrograms/meter^3.
5. Ventilation to optimize plant growth may dictate requirements.
6. Exhaust to outside; source control as required.
7. Installed equipment must incorporate positive exhaust & control (as required) of undesirable contaminants (toxic or otherwise).
8. Thermal effects probably determine requirements.
9. Distribution must consider worker location and concentration of running engines; stands where engines are run must incorporate systems for positive engine exhaust withdrawal.
10. Special ventilation will needed to eliminate special stage effects (e.g., dry ice vapors, mists, etc.).
11. The same for air supported structures.
12. Special solvent and exhaust problems handled separately.
13. Special contaminant control systems may be required.
14. Special requirements or codes may determine requirements.
15. Special exhaust systems required.
16. Floor area behind firing line only.

Chapter 4
BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH (STANDARD DESIGN)

400. GENERAL.

The criteria of this Chapter establish the minimum requirements for thermal design of the exterior envelope of buildings and for HVAC systems and its parts.

401. (RESERVED.)

402. OVERALL THERMAL PERFORMANCE AND BUILDING ENVELOPE REQUIREMENTS.

(a) The stated U_o value of any one element of a building, such as roof/ceiling, wall or floor, may be increased and the U_o value for other components decreased provided that the overall heat gain or loss for the entire building envelope does not exceed the total resulting from the conformance to the stated U_o values.

(b) Where return air ceiling plenums are employed, the roof/ceiling assembly area shall:

1. For thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly; and

2. For gross area purposes, be based upon the interior face of the upper plenum surface.

(c) U_o values listed in Tables 4-2, 4-3, and 4-4 refer to component assembly only. Credit for buffering from adjacent unheated spaces is not allowed when calculating U_o values.

(d) Exemption for Passive Solar features. Glazing areas which meet all of the following criteria may be exempted from the U_o calculations. Exempted glazing shall not be included in the gross wall area.

1. For buildings that have Electric Resistance heating systems, the glazing area must have a tested thermal transmittance (U) value of less than .61. For other heating systems, the glazing area need not be tested, but must be double glazed. (See Section 403(e).)

2. The south glazing shall be oriented within 45 degrees of true south.

3. The glazing shall be mounted at least 60 degrees up from the horizontal.

4. The glazing shall have a transmission coefficient greater than or equal to 0.80 for visible light or greater than or equal to 0.73 for total solar radiation.

5. Documentation shall be provided in the form of a sun chart, a photograph, or approved evidence, demonstrating that the glazing area shall not be shaded for at least 4 hours between 8 a.m. and 4 p.m. standard time on January 21 and March 21.

6. The building shall contain a heat capacity equivalent to at least 20 Btu/degree F-ft^2 for each square foot of south glazing when the south glazing area is between 10% and 14% of the buildings gross floor area, and at least 45 Btu/degree F-ft^2 for each square foot of south glazing when the south area glazing exceeds 14 percent of gross floor area. This heat storage capacity shall be located inside the insulated shell of the structure and not covered with insulation materials, such as carpet, which yield an R value of

1.0 or greater. If the storage medium is not within the space containing the south glazing, an approved natural or mechanical means of transferring the heat to the heat storage medium shall be provided. Heat storage capacity shall be calculated using the below equation and/or accepted analytical methods:

$HS = D \times SH \times V$

Where:

HS = Heat Storage. The heat storage capacity available inside the insulated space.

V = Volume of heat storage components.

D = Density of material inside the insulated shell of the building to a depth yielding a thermal resistance of R-1, except in the case of slab floors where only the slab itself is credited. Mass located in conditioned or unconditioned basements without solar glazing shall not be counted (lbs/cu ft).

SH = Specific heat of the material (Btu/lb/°F).

(e) **Insulation.**

1. **General.** Thermal and acoustical insulation located on or within floor/ceiling and roof/ceiling assemblies, crawl spaces, walls, partitions, and insulation on pipes and tubing shall comply with this section. Duct insulation shall conform to Section 416 and Table 4-16.

EXCEPTIONS:

A. Roof insulation shall comply with Section 3204 of the Uniform Building Code.

B. Roof insulation in vaulted ceilings over 3 in 12 shall conform with Section 3204 of the Uniform Building Code.

C. Exposed deck ceiling insulation shall conform with Section 3204 of the Uniform Building Code.

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 not to exceed 25 and a smoke density not to exceed 450 when tested in accordance with UBC Standard No. 42-1.

EXCEPTIONS:

A. Foam plastic insulation shall comply with Section 1717 of the Uniform Building Code.

B. 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.

C. Cellulose insulation shall conform to Section 1713 of the Uniform Building Code.

3. **Ventilation.** Enclosed joist or rafter spaces formed where ceilings are applied directly to the underside of roof joists or rafters must have joists or rafters of sufficient size to provide a minimum of one inch clear vented air space above the insulation (See also Section 3205 (c) of UBC). Ceiling insulation may be tapered or compressed at the perimeter to permit proper venting.

(f) **Moisture Control.**

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

A. Walls.

Walls separating conditioned space from unconditioned space shall have a vapor retarder installed when thermal insulation is installed. The vapor retarder shall have a one perm dry cup rating or less. Inset stapled batts with a perm rating less than one may be installed if staples are placed not more than (8) inches on center and gaps between the facing and the framing do not exceed (1/16) of an inch.

B. Roof/Ceilings.

i. Roof/ceiling assemblies where the ventilation space above the insulation is less than an average of twelve (12) inches shall be provided with a vapor retarder having a dry cup perm rating of 1.0 or less.

ii. Vapor retarders shall not be required in roof/ceiling assemblies where the ventilation space above the insulation averages twelve (12) inches or greater.

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

iv. Vapor retarders with a 1.0 or less dry cup perm rating polyethylene or an approved equal shall be installed in roof/ceiling assemblies where the insulation is comprised of insulation between the roofing membrane and the structural roof decking and insulation below the structural roof decking.

C. Ground Cover.

A ground cover of 4 mil (0.004 inch thick) polyethylene or approved equal shall be laid over the ground within crawl spaces. The ground cover shall be overlapped twelve (12) inches minimum at joints and shall extend to the foundation wall.

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

403. THERMAL PERFORMANCE CRITERIA AND ENVELOPE REQUIREMENTS FOR LOW-RISE RESIDENTIAL BUILDINGS.

Criteria for Residential Buildings three (3) stories or less as defined in UBC: Group R-3--detached one and two family dwellings; Group R-Div. 1--All other residential buildings three stories or less.

(a) The overall average thermal transmittance value of the gross area of the elements of the exterior building envelope of a low-rise residential building shall not exceed the values given in Table 4-2. Equations 1 and 2 in Section 404 shall be used to determine acceptable combinations of building components and thermal properties to meet this requirement.

(b) Floors over unheated spaces, such as unheated basements, unheated garages, or ventilated crawl spaces, shall be constructed to comply with the required values as specified in Table 4-2.

EXCEPTION: Insulation may be omitted from floor areas over heated basements, heated garages, or under floor areas used as HVAC plenums or

where openable foundation vents are used and when foundation walls are insulated. When foundation walls are insulated, the insulation shall be attached in a permanent manner.

(c) **Slab on Grade Floor.** 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 4-2. The insulation shall extend downward from the top of the slab for a minimum distance of 24 inches or downward to the bottom of the slab then horizontally beneath the slab for a minimum total distance of 24 inches. Insulation installed outside the foundation shall extend downward a minimum of 6 inches below grade but not less than to the frostline and need not extend deeper than to the top of the footing.

(d) **Windows and Doors and Air Leakage.** (See Section 405).

(e) **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.

   EXCEPTIONS: Electric resistance elements which are integral to heat pump heating systems or when the total electric heat capacity in each individual dwelling unit does not exceed the greater of: 1) 1,000 watts per dwelling unit, or; 2) 1.0 watt per square foot of the gross floor area.

2. **Other.** All gas, wood (not meeting the provisions of Section 102 (a)2), oil, propane, and heat pump space heating systems, unless electric resistance is used as a secondary heating system. (See EXCEPTIONS, Electric Resistance, Section 403 (e) 1. above.)

(f) **Walls.** Exterior wall sections, walls in finished basements, and interior walls exposed to unheated spaces shall be constructed to comply with the required values as specified in Table 4-2.

EXCEPTION: Concrete or masonry foundation walls of unfinished basements that have one-foot or less of the wall above grade need not be included in the gross wall area nor meet the requirements of Table 4-2 until finished, provided that:

1. Any frame walls meet the requirements of Table 4-2;

2. The rim-joist are properly insulated; and

3. All walls that are more than an average of one-foot above grade meet the requirements of Table 4-2.

(g) **Glazing.** Where available, U values from the Window Thermal Testing results shall be used to calculate total Wall U_o. If untested, the following default U values shall be used for all types of glazing, including skylights, ornamental, and security glazing.

1. For untested double glazing of any type, U = .90; and

2. For untested single glazing of any type, U = 1.20.

EXCEPTION: U values for site built fixed lites shall use window thermal test results when available. If tested results are unavailable, the Building Official shall require documentation based on a tested value of a comparable window.

(h) **General Insulation Requirements for Loose Fill Insulation:** Blown or poured loose fill insulation may be used in attic spaces where the slope of the ceiling is not more than 3 feet in 12 feet and there is at least 30 inches of clear distance from the top of the bottom chord of the truss or ceiling joist to the underside of the roof 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.

404. THERMAL PERFORMANCE CRITERIA FOR ALL OTHER OCCUPANCIES.

(a) The overall average thermal transmittance value (U_O) of the gross area of elements of the exterior building envelope of all buildings other than low-rise residential buildings shall not exceed the values given in Tables 4-3 and 4-4. Equations 1 and 2 shall be used to determine acceptable combinations of building components and thermal properties to meet this requirement for heating. U values for windows used to calculate total wall U_O shall be determined in accordance with accepted engineering practice. U_O and U_W are specified in units of:

$$\frac{\text{Btu}}{\text{hr. sq. ft. }^{\circ}\text{F}}$$

(b) Floors over unheated spaces shall not exceed the U_O value given in Table 4-3 and 4-4.

(c) **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 4-3 and 4-4.

Insulation installed inside the foundation shall extend downward from the top of the slab for a minimum distance of 24 inches, or downward to the bottom of the slab; then horizontally beneath the slab for a minimum total distance of 24 inches. Insulation installed outside the foundation shall extend downward 12 inches below grade or frostline or to the top of the footing.

(d) Alternative Wall Allowance for Low-rise Nonresidential Occupancies.

1. For nonresidential occupancy buildings, 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 4-4 provided that at least one of the following criteria is also met:

   A. 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 non-occupancy, or

   B. The primary source of heating for the building shall be one or more heat pumps meeting the provisions of Section 411(b) or gas or oil combustion heating equipment with a minimum combustion efficiency of 85 percent for central heating plants and 80 percent for room and space heaters. This efficiency shall be determined in accordance with the provisions of Section 411(c).

   Provided further: that if both criteria are met, the maximum allowed value for average thermal transmittance (U_O) of the exterior walls used in Table 4-4 may be increased by 0.05 in determining compliance with the provisions of the Code.

2. For walls with a wall weight of at least 30 lbs. per sq. ft. (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) of at least 2.25 sq. ft./hr.-°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 resistence of air films or additional exterior wall elements may be increased by 25 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.

EQUATION 1

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

Where:

U = the thermal transmittance of the assembly

r_o = outside air film resistance,

r_o = .17 for all exterior surfaces in winter

r_o = .25 for all exterior surfaces in summer

r_i = inside air film resistance,

r_i = .61 for interior horizontal surfaces, heat flow up

r_i = .92 for interior horizontal surfaces, heat flow down

r_i = .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

X = the thickness of the material

EQUATION 2

$$U_o = \frac{U_w A_w + U_g A_g + U_d A_d \ldots\ldots}{A}$$

Where:

U_o = the average or combined transmittance of the gross exterior wall, floor or roof/ceiling asembly area (except slabs on grade)

A = the gross exterior wall, floor or roof/ceiling assembly area.

U_w = the thermal transmittance of the components of the opaque wall, floor or roof/ceiling assembly area.

A_w = opaque wall, floor or roof/ceiling assembly area.

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

A_g = glazing area.

U_d = the thermal transmittance of the door, or similar opening.

A_d = door area.

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 expended into sub-elements as:

$U_{w1}A_{w1} + U_{w2}A_{w2} + U_{w3}A_{w3} + ...$etc.

405. AIR LEAKAGE FOR ALL BUILDINGS.

The requirements of this section shall apply to all buildings and structures and only to those locations separating outdoor ambient conditions from interior spaces that are heated or mechanically cooled. The requirements of this section are not applicable to the separation of interior conditioned spaces from each other.

(a) Exterior joints around windows and door frames, openings between walls and foundation, between walls and roof and between wall panels; openings at penetrations of utility services through walls, floors and roofs; and all other such openings in the building envelope shall be sealed, caulked, gasketed, or weatherstripped to limit air leakage.

(b) All exterior doors or doors serving as an access to an enclosed unheated area shall be weatherstripped to limit air leakage around their perimeter when in a closed position. Doors meeting the infiltration requirements of Table 4-8 shall be deemed to comply.

(c) All exterior windows shall be designed to omit air leakage into or from the building envelope. Manufactured windows shall have air infiltration rates no greater than those shown in Table 4-8.

Compliance with the criteria for air leakage of all types of doors shall be determined by Standard ASTM E 283-73, Standard Method of Test for Rate of Air Leakage through exterior windows, curtain walls and doors.

EXCEPTION: Site built windows are exempt from testing but shall be made tightly 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 required to be protected by fire resistive assemblies are exempt from this section.

406. BUILDING MECHANICAL SYSTEMS.

The following sections cover the determination of heating and cooling loads, design requirements, and equipment and component performance and control requirements. Requirements are established for insulating HVAC systems and for duct construction.

EXCEPTIONS: 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.

407. CALCULATIONS OF HEATING AND COOLING LOADS AND SYSTEM SIZING LIMITS.

(a) 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.

(b) The design parameters specified in Chapter 3 shall apply for all computations.

(c) 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 150 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 56,000 Btu/h or less may exceed the 150 percent sizing limit provided that the installed equipment has an annual fuel utilization efficiency (AFUE) of not less than the sum of 74 percent plus 1 percent for every 5,000 Btu/h that the space heating equipment output exceeds the design heating load of the dwelling unit.

3. Stand-by equipment may be installed if controls and other devices are provided which allow redundant equipment to operate only when the primary equipment is not operating.

408. (RESERVED.)

409. 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 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 305.

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:
   - 30 percent or less of the peak supply volume.
   - The minimum allowed to meet ventilation requirements of Section 305 (Table No. 3-1)
   - 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 nondepletable energy sources. In addition, the system shall comply with Section 414 without exception.

3. Areas where specific humidity levels are required to satisfy process needs.

4. Special pressurization relationships or cross-contamination requirements are such that variable air volume systems are impractical (such as some areas of hospitals and laboratories). In these cases, supply air temperatures shall be reset by representative building load or by outside air temperature.

410. ENERGY RECOVERY.

Consideration shall be given to the use of recovery systems which will conserve energy (provided the amount expended is less than the amount recovered) when the energy transfer potential and the operating hours are considered. (See Chapter 5.)

411. HVAC EQUIPMENT PERFORMANCE REQUIREMENTS.

(a) The requirement of this section applies to equipment and component performance for heating, ventilating and air-conditioning systems. Where equipment efficiency levels are specified, approved 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 shown in Tables 4-9, 4-10 and 4-11.

(b) **HVAC-System Heating Equipment Heat Pumps--Heating Mode.** Heat pumps whose energy input is entirely electric shall have a Coefficient of Performance (COP heating, as defined herein) not less than the values shown in Table 4-12.

1. These requirements apply to, but are not limited to, unitary heat pumps (air source and water source) in the heating mode and to heat pumps in the packaged terminal air-conditioner and room air-conditioner forms in the heating mode. Field assembled unitary heat pumps, consisting of one or more components, shall comply with this section.

2. **Coefficient of Performance (COP) Heating.** The ratio of the rate of net heat output to the rate of total energy input, expressed in consistent units and under designated rating conditions.

   The rate of net heat output shall be defined as the change in the total heat content of the air entering and leaving the equipment (not including supplementary heat).

   Total energy input shall be determined by combining the energy inputs to all elements, except supplementary heaters, of the heat pump, including, but not limited to, compressor(s), pump(s), supply-air fan(s), return-air fan(s), outdoor-air fan(s), cooling-tower fan(s), and the HVAC-system equipment control circuit.

3. **Supplementary Heater.** The heat pump shall be installed with a control to prevent supplementary heater operation when the heating load can be met by the heat pump alone. Supplementary heater operation is permitted during transient periods, such as start-ups, following room thermostat set-point advance, and during defrost, when the outdoor air temperature is below 55°F.

A two-stage thermostat, which controls the supplementary heat on its second stage, with outdoor air control, shall be accepted as meeting this requirement. 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. Supplementary heat may be derived from any source of electric resistance heating or combustion heating.

(c) **HVAC-System-Combustion Heating Equipment.** All commercial gas and oil-fired central heating plants shall show a minimum combustion efficiency of not less than those shown in Table 4-5. All residential gas, oil, and propane central heating systems must have a minimum AFUE of .74. All other residential heating equipment fueled by gas, oil, or propane must be equipped with an intermittent ignition device.

(d) **Mechanical Ventilation.** Each mechanical ventilation system (supply and/or exhaust) shall be equipped with a readily accessible or automatic means for either shut-off or volume reduction and shut-off when ventilation is not required.

(e) **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 show a Coefficient of Performance (COP) cooling as defined herein not less than values shown in Table 4-13.

1. These requirements apply to, but are not limited to unitary cooling equipment (air-cooled, water-cooled and evaporatively-cooled); the cooling mode of unitary and packaged heat pumps (air source and water source); packaged terminal air-conditioners; and room air-conditioners.

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

2. **Coefficient of Performance (COP) Cooling.** The ratio of the rate of net heat removal to the rate of total energy input, expressed in consistent units and under designated rating conditions.

   The rate of net heat removal shall be defined as the change in the total heat contents of the air entering and leaving the equipment (without reheat).

   Total energy input shall be determined by combining the energy inputs to all elements of the equipment, including but not limited to compressor(s), pump(s), supply-air fan(s), return-air fan(s), condenser-air fan(s), cooling tower fan(s), circulating water pump(s), and the HVAC-system equipment control circuit.

(f) **Applied HVAC-system components, electrically operated cooling-mode.** HVAC-system components, as listed in Table 4-14 whose energy input is entirely electric, shall show a Coefficient of Performance (COP) cooling, as defined herein, and not less than the values shown in Table 4-14.

1. **Coefficient of Performance (COP) Cooling.** The ratio of the rate of net heat removal to the rate of total energy input expressed in consistent units and under designated rating conditions.

   The rate of net heat removal is defined as the difference in total heat contents of the water or refrigerant entering and leaving the component.

Total energy input shall be determined by combining the energy inputs to all elements and accessories of the component, including but not limited to, compressor(s), internal circulating pump(s), condenser-air fan(s), evaporative-condenser cooling water pump(s), purge, and the HVAC-system component control circuit.

(g) **HVAC-system equipment--heat operated cooling mode.** Efficiency limitation equipment: Heat operated cooling equipment shall show a (COP) cooling not less than the values shown in Table 4-15. These requirements apply to, but are not limited to, absorption equipment, engine driven equipment, and turbine driven equipment.

(h) **Fireplaces.** Fireplaces shall be provided with:

1. Tightly fitting flue dampers, operated with a readily accessible manual or approved automatic control.

   EXCEPTION: Fireplaces with gas logs installed in accordance with UMC 803 shall be equipped with tightly fitting glass or metal doors.

2. An outside source for combustion air. The duct shall be at least six square inches in area, and shall be provided with a readily operable damper.

412. ENERGY FOR AIR DELIVERY.

The air transport factor for nonresidential all-air HVAC systems shall not be 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/hr.

413. BALANCING.

The HVAC system design shall provide means for balancing air and water systems such as but not limited to dampers, temperature and pressure test connections and balancing valves.

414. COOLING WITH OUTDOOR AIR (ECONOMIZER CYCLE).

Each supply fan system shall be designed to use up to and including 100 percent of the fan system capacity for cooling with outdoor air automatically. Activation of economizer cycle shall be controlled by sensing outdoor air dry-bulb temperature or outdoor air enthalpy or alternative means approved by the Building Official.

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

(a) Fan system capacity less than 3,500 CFM or 90,000 Btu/hr total cooling capacity.

(b) The quality of the outdoor air is so poor as to require intensive treatment of the air.

(c) The need for humidification or dehumidification requires the use of more energy than is conserved by the outdoor air cooling.

(d) The use of outdoor air cooling may affect the operation of other systems so as to increase the overall energy consumption of the building.

(e) Internal/external zone heat recovery or other energy recovery is used, which is more efficient than using outdoor air.

(f) When all space cooling is accomplished by a circulating liquid which transfer space heat directly or indirectly to a heat rejection device such as a cooling tower without the use of a refrigeration system.

415. CONTROLS.

(a) **Temperature Control.** Each HVAC system shall be provided with at least one thermostat for the regulation of temperature. Where used to control both heating and cooling, each thermostat shall be capable of being set from 55-85°F and shall be capable of operating the system heating and cooling in sequence. It shall be adjustable to provide a temperature range of at least 10°F between full heating and full cooling.

(b) **Humidity Control.** If an HVAC system is equipped with a means for adding moisture to maintain specific selected relative humidities in spaces or zones, a humidistat shall be provided. This device shall be capable of being set to prevent new energy from being used to produce space relative humidity (rh) above 30 percent rh. Where a humidistat is used in an HVAC system for controlling moisture removal to maintain specific selected relative humidities in spaces or zones, it shall be capable of being set to prevent new energy from being used to produce a space relative humidity below 60 percent relative humidity.

EXCEPTION: Special occupancies requiring different relative humidities may be permitted by the Building Official.

(c) **Zoning for Temperature control.**

1. **One and Two-Family Dwellings.** At least one thermostat for regulation of space temperature shall be provided for each separate HVAC 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 not controlled by a thermostat.

2. **Multifamily Dwellings.** For multifamily dwellings, each individual dwelling unit shall be considered separately and shall meet the above requirements. Spaces other than living units shall meet the requirements of Section 415 (c) (3).

3. **All Other Types of Buildings or Occupancies.** At least one thermostat for regulation of space temperature shall be provided for:

   A. Each separate HVAC system.

   B. Each separate zone. As a minimum each floor of a building shall be considered as a separate zone. In a multi-story 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 restrict partially or shut off the heating and/or cooling input (for the exposure) to each floor.

4. Control Setback and Shut-off.

   A. **Residential Occupancy Groups.** One-and-Two-Family and Multifamily dwellings--The thermostat required in paragraphs 1 and 2 of this subsection (c) 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.

8. **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:

   i. Manually adjustable automatic timing devices.

   ii. Automatic control systems.

416. AIR HANDLING DUCT SYSTEM INSULATION.

All ducts, plenums and enclosures installed in or on buildings shall be thermally insulated to meet the requirements of Table 4-16.

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

(a) Supply or return air ducts installed in unvented crawl spaces with insulated walls, basements or cellars in one- and two-family dwellings.

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

(c) Within the HVAC equipment.

(d) Exhaust air ducts.

417. DUCT CONSTRUCTION.

All duct work shall be constructed and erected in accordance with the Uniform Mechanical Code.

418. PIPING INSULATION.

All piping installed to serve buildings (and within) shall be thermally insulated in accordance with Table 4-17, except as stated herein, (for recirculating service water heating systems, see Section 422).

(a) **Other Insulation Thickness.** Insulation thickness in Table 4-17 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.

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

$$\frac{4.6 \times \text{Table 4-17 Thickness}}{\text{Actual R}} = \text{New Minimum Thickness}$$

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

$$\frac{4.0 \times \text{Table 4-17 Thickness}}{\text{Actual R}} = \text{New Minimum Thickness}$$

(b) **Exceptions.** Piping insulation is not required in any of the following cases:

1. Piping installed within unitary HVAC equipment.

2. Piping at temperatures between 55°F and 100°F.

3. When the heat loss and/or heat gain of the piping, without insulation, does not increase the energy requirements of the building or is used as a component of a designed Heating System.

(c) Additional insulation with vapor barriers shall be provided to prevent condensation where required.

419. (RESERVED.)

420. WATER HEATERS, STORAGE TANKS, BOILERS, AND PIPING.

(a) **Performance Efficiency.**

1. Gas, oil-fired water heaters and electric storage water heaters shall meet the requirements of ASHRAE Standard 90A-80 and be so labeled.

   All electric water heaters in unheated spaces shall be placed on an incompressible, insulated surface with a minimum thermal resistance of R-10. Electric water heaters placed on floors insulated to a minimum of R-10 shall be deemed to meet with this requirement.

(b) **Temperature Controls.**

1. 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.

2. **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 heating systems.

3. **Swimming Pools.**

   Heated swimming pools shall be equipped with:

   A. A pool cover at the surface of the water.

   B. A label on the pool heater that provides the following information: (The following recommendations replace requirements for temperature and on/off controls.) Pool heating--78°F is the recommended healthful swimming pool temperature for most people. The water heater thermostat should be set at 78°F, marked to identify that setting, and further adjustments should be discouraged. An increase of 4°F (such as from 78°F to 82°F) could increase energy consumption by as much as 40 percent.

      Filter System--the time clock for operating the filter system should be set to operate the filter system for the minimum number of hours of operation required to maintain clean and healthful pool water.

      Pool Cover--it is recommended that the pool be covered except when the pool is in use. Use of the cover can cut pool heating costs by as much as 70 percent.

421. PUMP OPERATION.

Circulating hot water systems shall be arranged so that the circulating pump(s) can be conveniently turned off, automatically or manually, when the hot water system is not in operation.

422. PIPE INSULATION.

For recirculating systems, piping heat loss shall be limited to a maximum of 25 Btu/hr ft^2 of external pipe surface for above ground piping and a maximum of 35 Btu/hr ft^2 of external pipe surface for underground piping. Maximum heat loss shall be determined at a temperature differential equal to the maximum water temperature minus a design ambient temperature no higher than 65 degrees F.

423. CONSERVATION OF HOT WATER.

(a) Showers used for other than safety reasons shall be equipped with flow control devices to limit total flow to a maximum of 3 gpm per shower head.

(b) Lavatories in restrooms of public facilities shall be equipped with outlet devices which limit the flow of hot water to a maximum of 0.5 gpm or equipped with self-closing valves.

424. ELECTRICAL POWER AND LIGHTING.

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.

425. 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 20 ampere circuit loaded to no more than 80 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 200 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 12 feet of a window wall or the zone between an interior wall and the window wall of less than 12 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.

426. 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 426.

(a) **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.

(b) **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 No. 4-18.

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 30 percent shall be allowed for any single space up to 400 square feet and enclosed by ceiling height partitions; classrooms, conference rooms, computer rooms, storage areas, corridors, or waiting rooms.

B. For daylighting controls, energy savings of 30 percent for continuous dimming and 20 percent for stepped controls shall be allowed for any daylit space.

C. For lumen maintenance controls, energy savings of 10 percent shall be allowed for any space.

D. For daylighting controls with occupant-sensing devices, energy savings of 44 percent shall be allowed for any single space up to 400 square feet within daylit spaces, and enclosed by ceiling height partitions.

E. For occupant-sensing devices with lumen maintenance controls, energy savings of 37 percent shall be allowed for any single space up to 400 square feet and enclosed by ceiling height partitions.

2. 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.

(c) **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 square foot of area. Lighting for signs that are not an integral part of the building shall be exempted fron inclusion in these calculations.

TABLE 4-1
CLASSIFICATION OF BUILDING OCCUPANCIES

	All Group R Occupancy Space	Other than Group R Occupancy Space
Three conditioned stories and less	Table 4-2	Table 4-3
More than three conditioned stories	Table 4-4	Table 4-4

TABLE 4-2
LOW-RISE RESIDENTIAL BUILDINGS
MAXIMUM ALLOWED U_o VALUES
AND MINIMUM ALLOWED R VALUES

Heat Type	Climatic Zone	Roofs Ceilings	Cathedral Ceilings	Walls (Includes Glazing)	Floors	Slab on Grade[1]
		U_o	U_o	U_o	U_o	Installed R Value
Electric Resistance	I	0.026	0.035	0.144	0.055	8
Other	I	0.035	0.035	0.203	0.055	8
Electric Resistance	II	0.026	0.035	0.144	0.043	10
Other	II	0.035	0.035	0.203	0.055	10

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

TABLE 4-3
NONRESIDENTIAL OCCUPANCIES
BUILDINGS 3 STORIES OR LESS
MAXIMUM ALLOWED U_o VALUES AND
MINIMUM ALLOWED R VALUES

Zone	Ceilings	Walls (Includes Glazing)	Floors	Slab on Grade[1]
	U_o	U_o	U_o	Installed R Value
I	0.035	0.25	0.05	8
II	0.035	0.20	0.05	10

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

TABLE 4-4
ALL OCCUPANCIES
BUILDINGS OVER 3 STORIES
MAXIMUM ALLOWED U_o VALUES AND
MINIMUM ALLOWED R VALUES

Zone	Ceilings	Walls (Includes Glazing)	Floors	Slab on Grade[1]
	U_o	U_o	U_o	Installed R Value
I	0.08	0.30	0.08	8
II	0.06	0.25	0.08	10

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

TABLE 4-5
NONRESIDENTIAL 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 Furnaces 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 4-6
(RESERVED)

TABLE 4-7
(RESERVED)

TABLE 4-8
ALLOWABLE AIR INFILTRATION RATES

WINDOWS (cfm per lineal foot of operable sash crack)	RESIDENTIAL DOORS Swinging and Sliding (cfm per square foot of door)	COMMERCIAL DOORS Swinging, Sliding, Revolving (cfm per lineal foot of crack)
0.5	0.5	11.0

[1] When tested at a pressure differential of 1.567 lb/ft.^{2}, which is equivalent to the impact pressure of a 25 mph wind.

TABLE 4-9
HVAC SYSTEM HEATING EQUIPMENT (HEAT PUMPS)
STANDARD RATING CONDITIONS

CONDITIONS		TYPE: AIR SOURCE		TYPE: WATER SOURCE
Air entering equipment	°F.	70DB	70DB	70DB
Outdoor unit ambient	°F.	47DB/43WB	17DB/15WB	--
Entering water temperature	°F.	--	--	60
Water flow rate		--	--	As used in cooling mode

TABLE 4-10
HVAC SYSTEM EQUIPMENT
STANDARD RATING CONDITIONS -- COOLING

		TEMPERATURES: DB	WB	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.
Note: db = dry bulb
wb = wet bulb

TABLE 4-11
APPLIED HVAC SYSTEM COMPONENTS
STANDARD RATING CONDITIONS -- COOLING

ITEM			CENTRIFUGAL OR SELF-CONTAINED RECIPROCATING WATER-CHILLER	CONDENSERLESS RECIPROCATING WATER-CHILLER
Leaving chilled water temp.		°F.	44	44
Entering chilled water temp.		°F.	54	54
Leaving condenser water temp.		°F.	95	--
Entering water temp.		°F.	85	--
Fouling factor, water				
Non-ferrous tubes		*	0.0005	0.0005
Steel tubes		*	0.0010	0.0010
Fouling factor, refrigerant		*	0.0000	0.0000
Condenser ambient (Air or evap. cooled)		°F.	95DB/75WB	--
Compressor saturated discharge temp.	Water cooled (or evap. cooled)	°F.	--	105
	Air cooled	°F.	--	120

Standard ratings are at sea level.

* $h.ft.^2°F./Btu$

TABLE 4-12
HVAC-SYSTEM HEATING EQUIPMENT (HEAT PUMPS)
MINIMUM COP & HSPF FOR HEAT PUMPS, HEATING MODE

SOURCE AND OUTDOOR TEMPERATURE (°F)	MINIMUM COP	MINIMUM HSPF
Air Source--47DB/43WB	2.7	-
Air Source--17DB/15WB	1.8	-
Air Source	-	6.35
Water Source--60 Entering	3.0	-
Ground Source	3.0	

[1]When tested at the standard rating specified in Table 4-9

TABLE 4-13
MINIMUM EER AND COP-COOLING FOR
ELECTRICALLY DRIVEN HVAC SYSTEM EQUIPMENT-COOLING[1]

STANDARD RATING CAPACITY	AIR-COOLED		EVAP. OR WATER-COOLED	
	EER	COP	EER	COP
Under 65,000 Btu/hr (19,050 watts)	7.8	2.28	8.8	2.58
65,000 Btu/hr (19,050 watts) and over	8.2	2.40	9.2	2.69

[1]The U.S. Department of Energy has established required test procedures for single-phase, air-cooled, residential central air-conditioners under 19 KW (65,000 Btu/h) capacity, which have been incorporated into ARI Standard 210-79. EER and COP values in Table 4-13 are based on Test A of DOE Test Procedures.

TABLE 4-14
MINIMUM EER AND COP FOR ELECTRICALLY DRIVEN HVAC-SYSTEM COMPONENTS[1]

WATER CHILLING PACKAGES

		CONDENSING MEANS					
		AIR		WATER		EVAPORATIVE	
COMPONENT	TYPE	EER	COP	EER	COP	EER	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 (19,050 watts) and over[2]	Positive displacement	9.50	2.78	12.50	3.66	12.50	3.66

HYDRONIC HEAT PUMPS

COMPONENT	TYPE	EER	COP
Water source under 65,000 Btu/h (19,000 watts)	Centrifugal or rotary	9.00	2.64
Water source 65,000 Btu/h (19,000 watts) and over	Centrifugal or rotary	9.40	2.75

[1]When tested at the standard rating conditions specified in Table No. 4-9, 4-10, and 4-11.
[2]Ratings in accordance with Standard for Positive Displacement Refrigerant Compressor and Condensing Units, ARI Standard 520-74 as applicable. COP based on condensing unit standard rating capacity and energy input to the unit, all at sea level.

TABLE 4-15
HVAC-SYSTEM HEAT-OPERATED COOLING EQUIPMENT

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

$$\text{Minimum COP} = \frac{\text{Net cooling output}}{\text{Total heat input (electrical auxiliary inputs excluded)}}$$

TABLE 4-16
INSULATION OF DUCTS

DUCT LOCATION	INSULATION TYPES MECHANICALLY COOLED	CLIMATE ZONE	INSULATION TYPES HEATING ONLY
On roof or on exterior of building	C, V[2] and W D, V[2] and W	I II	C and W D and W
Attics, garages and crawl spaces, in walls[1], within floor-ceiling spaces[1]	B and V[2] C and V[2]	I II	B C
Within the conditioned space or in basements	None Required		None Required
Cement slab or within ground	A		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:

A. 0.5-inch 1.5 to 2 lb/cu. ft. duct liner, mineral or glass fiber blanket or equivalent to provide an installed 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 thermal resistance of at least R-6.

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 thermal resistance of at least R-8.

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 thermal resistance of at least R-12.

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

W. Approved weatherproof barrier.

TABLE 4-17
MINIMUM PIPE INSULATION

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGE, °F	INSULATION THICKNESS IN INCHES FOR PIPE SIZES[2] RUN-OUTS UP TO 2"[1]	1" AND LESS	1.25" TO 2"	2.5" TO 4"	5" TO 6"	8" AND LARGER
HEATING AND HOT WATER SYSTEMS							
Steam and hot water							
High pressure/temp.	306-450	1.5	2.5	2.5	3.0	3.5	3.5
Med. pressure/temp.	251-305	1.5	2.0	2.5	2.5	3.0	3.0
Low pressure/temp.	201-250	1.0	1.5	1.5	2.0	2.0	2.0
Low temperature	100-200	.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	40-55	.5	.5	.75	1.0	1.0	1.0
Refrigerant, or brine	Below 40	1.0	1.0	1.5	1.5	1.5	1.5

[1] Runouts not exceeding 12 feet in length to individual terminal units.

[2] For piping exposed to outdoor air, increase thickness by .5 inch.

TABLE 4-18
INTERIOR LIGHTING POWER BUDGET[1]

	GROUP OCCUPANCY DESCRIPTION	LIGHTING POWER BUDGET[2] (W/sq ft)
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 s.f.	4.0
	6000 to 20,000 s.f.	3.0
	over 20,000 s.f.	2.0
	Drinking and dining establishments	1.85
	Food preparation task light	Exempt
	Aircraft hangars - storage	0.7
	Process plants[3]	1.0
	Factories and work shops[3]	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/sq. ft. 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 5

BUILDING DESIGN BY SYSTEMS ANALYSIS AND BUILDINGS UTILIZING NONDEPLETABLE ENERGY SOURCES

500. GENERAL.

This chapter establishes design criteria in terms of total energy use by a building including all of its systems.

501. ENERGY ANALYSIS.

Compliance with this section will require an annual energy analysis.

A building designed in accordance with this chapter (the "alternative design building") will comply with this Code if the annual energy consumption is not greater than that of a building of similar design (a "standard design") whose enclosure elements and energy consuming systems are designed in accordance with Chapter 4 or Chapter 6. The calculated energy consumption of the alternative design shall be subject to a limitation in the improvement credited to any individual building system as outlined in Section 503.

"Building of similar design" shall mean a building utilizing the same energy source(s) for the same functions and having equal floor area, environmental requirements, occupancy, climate data and usage schedule. Inputs to the energy analysis relating to occupancy and usage shall correspond to the expected occupancy and usage of the building.

The alternative design shall incorporate the applicable provisions of Section 415 (mechanical system controls), Section 420(b) (water temperature control), and Section 425 (lighting switching).

502. DESIGN.

The standard design, conforming to the criteria of Chapter 4 or Chapter 6 and the proposed alternative design shall be designed on a common basis as specified herein. The glazing area to be used in the standard design of low-rise residential occupancy buildings shall not exceed 15% of the floor area.

The comparison of total energy usage shall be expressed in Btu per square foot or in KWH per square foot of gross floor area per year for the standard design and the alternative design. Comparison of similar elements, systems or components shall be expressed in dimensions or terms accepted by standard engineering practice.

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

503. ANALYSIS PROCEDURE.

The analysis of the annual energy usage of the standard design 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 of sufficient detail to permit the evaluation of effect of factors specified in Section 504.

(b) The calculation procedure used to simulate the operation of the building and its service systems through a full year operating period shall be of sufficient detail to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data shall be used when available in the simulation of all systems and equipment. The calculation procedure shall be based upon operation of the building and its service systems through a typical year. Variations in climatic data shall be represented.

(c) The calculation procedure for the standard design and the proposed alternative design shall separately identify the energy input to each of the following systems: heating, cooling, ventilation, and lighting. The energy input to any other system using over ten percent of the total energy input shall also be separately identified. The energy use for the standard and alternative designs shall be calculated by summing the energy inputs assigned to each identified system and all other energy inputs not separately identified. The systems identified, and, to the extent possible, the assumptions made in assigning energy inputs to each system, shall be the same for the standard design and the proposed alternative design. When electrically driven heat pumps are employed to provide all or part of the heat for the alternative design, the standard design shall also, for the purposes of the analysis, assume that electrically driven heat pumps in conformance with Section 411 and having capacity at least as great as those used in the alternative design are employed.

(d) The energy use assigned to each building system in the proposed alternative design shall be as calculated in subsection (c) or eighty percent of the use calculated for the same system in the standard design in subsection (c), whichever is greater.

504. CALCULATION PROCEDURE.

The calculation procedure shall cover the following items:

(a) Design requirements: Design parameters required in Chapter 3.

(b) Climatic data: Coincident 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.

505. DOCUMENTATION.

A proposed alternative design submitted under this Chapter shall be accompanied by an energy analysis comparison report. The report shall provide sufficient technical detail on the two buildings and their systems and on the data used in and resulting from the comparative analysis to certify that both the analysis and the designs meet the criteria of this Code.

The Documentation shall demonstrate that the analysis used is consistent with accepted techniques and procedures.

EXCEPTION: Proposed alternative designs for single family and two family dwellings and for commercial and industrial structures having the indoor temperature controlled from a single point need not provide the energy usage analysis for a full year. A comparison of energy consumption between the alternative design and the standard design in a manner which follows approved engineering practices and standards, as approved by the Building Official, shall be provided.

506. BUILDINGS UTILIZING NONDEPLETABLE ENERGY.

(a) Buildings utilizing solar, geothermal, wind or other nondepletable energy sources for all or part of its energy source shall meet the requirements of this Chapter of this Code. The energy derived from the nondepletable source may be excluded from the total annual energy consumption attributed to the alternate design building by this chapter.

(b) This section shall also apply to passive cooling processes in lieu of energy consuming processes.

(c) All other criteria covered in this Chapter and Chapter 4 shall apply to the proposed alternative designs utilizing nondepletable sources of energy.

507. DOCUMENTATION--BUILDINGS USING NONDEPLETABLE ENERGY SOURCES.

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

The energy derived from nondepletable sources and the reduction in conventional energy requirements derived fron nocturnal cooling shall be separately identified from the overall building energy use. Supporting documentation, on the basis of the performance estimates for the aforementioned nondepletable energy sources or nocturnal cooling means, must be submitted.

Energy usage must be calculated in accordance with the design conditions and methods specified in this Code.

Chapter 6

PRESCRIPTIVE REQUIREMENTS APPROACH

600. GENERAL.

(a) This Chapter establishes design criteria in terms of prescribed requirements for building construction.

(b) The requirements contained in this Chapter are applicable only to buildings less than 10,000 square feet in gross floor area or low-rise residential buildings. Other methods may be used provided a satisfactory design is submitted showing compliance with the performance standards of this Code.

(c) Installed insulation having a minimum R value as specified in this Chapter shall be accepted as providing the corresponding required U value.

601. LOW-RISE RESIDENTIAL BUILDING ENVELOPE REQUIREMENTS.

For all components except for walls, the R values specified in Table 6-1 are for installed insulation material only. R values for construction are defined as any combination of rigid-sheathing, loose fill, or batt insulation that achieves the prescribed R value. Where insulation is installed in a continuous manner and is not interrupted by occasional framing members, its R value may be increased by 20% in determining compliance with the requirements of this table. This allowance does not apply to insulation of slab on grade or walls.

(a) **Walls.** The total assembly of opaque exterior wall sections, walls in finished basements, and the interior walls exposed to unheated spaces shall have a thermal resistance R value not less than the values specified in Table 6-1. Total wall assembly R values include values for insulation, sheathing, gypsum-board, air-films, concrete, etc. The following walls shall be considered to meet the R-19 total assembly criteria without additional documentation:

1. 2" x 6" with installed R-19 batt.

2. 2" x 4" with an installed R-13 batt and R-5 insulating sheathing.

3. 2" x 4" with an installed R-11 batt and R-5.4 insulating sheathing.

EXCEPTION: Concrete or masonry foundation walls of unfinished basements that have one foot or less of the wall above grade need not be insulated until finished, provided what:

A. Any frame walls comply with the requirements of Table 6-1;

B. The rim-joists are properly insulated;

C. All walls that are more than an average of one foot above grade are insulated to meet the requirements of Table 6-1.

(b) **Roof/ceiling.** The roof/ceiling assembly shall have a thermal resistance R value not less than the value specified for the indicated type of construction in Table 6-1.

EXCEPTION: Insulation levels in the case of single rafter or joist vaulted ceilings. These types of ceilings may be insulated to a level of R-30, regardless of space heat type.

(c) **Thermal Design Standards for Floors.**

1. **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 6-1.

Insulation installed inside the foundation shall extend downward from the top of the slab for a minimum distance of 24 inches; or downward to the bottom of the slab, then horizontally beneath the slab for a minimum total distance of 24 inches. Insulation installed outside the foundation shall extend downward a minimum of 6 inches below grade but not less than to the frostline and need not extend deeper than to the top of the footing.

2. **Floor Sections.** Floor sections over unheated spaces, such as unheated basements, unheated garages or ventilated crawl spaces, shall be constructed to comply with the required values as specified in Table 6-1.

EXCEPTION: Insulation may be omitted from floor areas over heated basements, heated garages, or under floor areas used as HVAC plenums or where openable foundation vents are used and when foundation walls are insulated. When foundation walls are insulated in accordance with Section 601(a), the insulation shall be attached in a permanent manner.

(d) **Thermal Design Standards for Openings.**

1. At a minimum, all windows must be double glazed, and are classed according to U values as shown on Table 6-2. Glazing requirements are listed in Table 6-4.

2. At a minimum, all skylights must be double glazed. The area of Class 90 skylights and Class 90 exterior windows sloped more than 30° from the vertical shall be doubled and this area included in the percentage of the total glazing area as allowed for in Table 6-4. Class 75 or Class 60 glazing in skylights or Class 75 or Class 60 windows sloped more than 30° from the vertical need not be doubled.

3. 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 Table 6-4. The maximum area (before doubling) allowed for the total of all single glazing is 1% of the floor area.

(e) **Air Leakage.**

1. **Windows and Doors.** All windows within a wall and doors shall conform to the air infiltration requirements specified in Section 405. Site built windows shall be constructed to minimize leakage.

EXCEPTION: Openings required to be protected by fire resistive assemblies are exempt from this section.

2. Exterior joints around windows and door frames, openings between walls and foundations, between walls and roof and between wall panels; openings at penetrations of utility services through walls, floors and roofs; and all other such openings in the building envelope shall be sealed, caulked, gasketed, or weatherstripped to limit air leakage.

(f) **Moisture Control.** Vapor retarders shall be installed on the warm side (in winter) of insulation as specified in the following cases:

1. Walls separating conditioned space from unconditioned space shall have a vapor retarder installed when thermal insulation is installed. The vapor retarder shall have a one perm dry cup rating or less. Inset stapled batts with a facing with a perm rating less than one may be installed if staples are placed not more than (8) inches on center and gaps between the facing and the framing do not exceed (1/16) of an inch.

.. Roof/ceilings.

A. Roof/ceiling assemblies where the ventilation space above the insulation is less than an average of twelve (12) inches shall be provided with a vapor retarder having a dry cup perm rating of 1.0 or less.

B. Vapor retarders shall not be required in roof/ceiling assemblies where the ventilation space above the insulation averages twelve (12) inches or greater.

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

D. Vapor retarders with a 1.0 or less dry cup perm rating shall be installed in roof/ceiling assemblies where the insulation is comprised of insulation between the roofing membrane and the structural roof decking and insulation below the structural roof decking.

3. **Ground Cover.**

A ground cover of 4 mil (0.004 inch thick) polyethylene or approved equal shall be laid over the ground within crawl spaces. The ground cover shall be overlapped twelve (12) inches minimum at joints and shall extend over the top of the footing.

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

(g) **General Requirements for Loose Fill Insulation.** Blown or poured loose fill insulation may be used in attic spaces where the slope of the ceiling is not more than 3 feet in 12 feet and there is at least 30 inches of clear distance from the top of the bottom chord of the truss or ceiling joist to the underside of the roof 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.

(h) **Space Heat Type.** The following four 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.

EXCEPTIONS: Electric resistance elements which are integral to either heat pump or passive solar heating systems (as defined below), or when the total electric heat capacity in each individual dwelling unit does not exceed the greater of: 1) 1,000 watts per dwelling, or; 2) 1.0 watt per square foot of the gross floor area.

2. **Electric, Passive Solar.** Electric resistance space heating systems which utilize solar energy to provide a portion of the building's heating load. A Passive Solar System is required to have at least ten (10) percent of the building's gross floor area in glazing that meets the specifications of Section 601(i).

3. **Other.** Includes all gas, wood (not meeting the provisions of Section 102 (a)2), oil, propane, and electric heat pump space heating systems, unless electric resistance is used as a secondary heating system. (See EXCEPTIONS, Electric Resistance, Section 601 (h) 1. above.) Nonelectric heat pump heating systems are also included in this category.

4. **Other, Passive Solar.** Other types of space heating systems which utilize solar energy to provide a portion of the building's heating load. A Passive Solar System is required to have at least ten (10) percent of the building's gross floor area in glazing that meets the specifications of Section 601(i).

(i) **Passive Solar Glazing.** Glazing areas are required to meet the following criteria in order to be considered Passive Solar Glazing.

1. Glazing areas are required to meet the "Electric, Passive Solar" and "Other, Passive Solar" glazing requirements of Table 6-4.

2. The south glazing shall be oriented within 45 degrees of true south.

3. The glazing shall be mounted at least 60 degrees up from the horizontal.

4. The glazing shall have a transmission coefficient greater than or equal to 0.80 for visible light or greater than or equal to 0.73 for total solar radiation.

5. Documentation shall be provided in the form of a sun chart, a photograph, or approved evidence, demonstrating that the glazing area shall not be shaded for at least 4 hours between 8 a.m. and 4 p.m. standard time on January 21 and March 21.

6. The building shall contain a heat capacity equal to a four inch concrete slab. The heat capacity shall be equivalent to at least 20 Btu/degree F-ft^2 for each square foot of south glazing when the south glazing area is between 10% and 14% of the building's gross floor area, and at least 45 Btu/degree F-ft^2 for each square foot of south glazing when the south area glazing exceeds 14 percent of gross floor area. In buildings with south glazing area between 10% and 14% of gross floor area, the heat capacity provided by a four inch concrete slab shall be deemed sufficient. This heat storage capacity shall be located inside the insulated shell of the structure and not covered with insulation materials, such as carpet, which yield an R value of 1.0 or greater. If the storage medium is not within the space containing the south glazing, an approved natural or mechanical means of transferring the heat to the heat storage medium shall be provided. Heat storage capacity shall be calculated using the below equation and/or accepted analytical methods:

$$HS = D \times SH \times V$$

Where:

HS = Heat Storage. The heat storage capacity available inside the insulated space.

V = Volume of heat storage components.

D = Density of material inside the insulated shell of the building to a depth yielding a thermal resistance of R-1, except in the case of slab floors where only the slab itself is credited. Mass located in conditioned or unconditioned basements without solar glazing shall not be counted (lbs/cu ft).

SH = Specific heat of the material (Btu/lb/°F).

(j) **Ventilation.** Enclosed joist or rafter spaces formed where ceilings are applied directly to the under side of roof joists or rafters must have joists or rafters of sufficient size to provide a minimum of one inch clear vented air space above the insulation (see also Section 3205 (c) of UBC). Ceiling insulation may be tapered or compressed at the perimeter to permit proper venting.

LOW-RISE RESIDENTIAL BUILDING MECHANICAL SYSTEMS.

All HVAC devices, components and their elements shall conform to the requirements of this section.

(a) **Heating and Mechanical Cooling Devices.**

1. All heating and mechanical cooling devices shall meet the required efficiency factor specified herein or in Tables 4-12, 4-13, 4-14, and 4-15, 6-3, and 6-4, for the specific type of device.

2. **Combustion Heating Equipment.** All gas and oil-fired heating equipment shall meet the minimum combustion efficiencies as specified in Table 6-4.

3. **Fireplaces shall be provided with:**

   A. Tightly fitting flue dampers, operated with a readily accessible manual or approved automatic control.

      EXCEPTION: Fireplaces with gas logs installed in accordance with UMC 803 shall be equipped with tightly fitting glass or metal doors.

   B. An outside source for combustion air. The duct shall be at least six square inches in area, and shall be provided with a readily operable damper.

4. **Calculation of Heating and Cooling Loads.** Heating and cooling design loads for the purpose of sizing HVAC systems are required and shall be calculated in accordance with accepted engineering practice. The design parameters specified in Chapter 3 shall apply for all computations. HVAC equipment for low-rise residential buildings shall be sized no greater than 150 percent of the design load as calculated above.

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

(b) **Temperature Control.**

Each heating system shall be provided with at least one thermostat for the regulation of temperature. Each thermostat shall be capable of being set as follows:

Where used to control heating only--55-75°;
Where used to control cooling only--70-85°;
Where used to control both heating and cooling, it shall conform to the requirements of Section 415.

(c) **Zoning for Temperature Control.**

1. **Group R-3 Occupancy**

At least one thermostat for regulation of space temperature shall be provided for each separate HVAC system. In addition, a readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating or cooling input to each zone or floor.

EXCEPTION: Nonconditioned basements and garages.

2. **Group R-1 Occupancy.**

For multifamily dwellings, each individual dwelling unit shall be considered separately and shall meet the requirements of Section 602. Spaces other than living units shall meet the requirements of section 415 (c) 3.

3. **Control Setback and Shutoff:** Group R-1 and R-3.

The thermostat required in (a) and (b) 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 periods of nonuse 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.

4. **Duct Insulation.**

All ducts, plenums and enclosures installed in or on buildings shall be thermally insulated and constructed in accordance with Section 416.

5. **Pipe Insulation.**

All piping installed to serve buildings or within buildings shall be thermally insulated in accordance with Table 4-17.

EXCEPTION: For service water heating systems, see Section 603.

603. LOW-RISE RESIDENTIAL BUILDING SERVICE WATER HEATING.

Water heating storage tanks, boilers and piping for all water heating systems shall be installed in accordance with the following:

(a) **Temperature 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.

(b) **Swimming Pools.**

Heated swimming pools shall be equipped with:

1. A pool cover at the surface of the water.

2. A label on the pool heater that provides the following information (the following recommendations replace requirements for temperature and on/off controls):

Pool heating--78°F is the recommended healthful swimming pool temperature for most people. The water heater thermostate should be set at 78°F, marked to identify the setting, and further adjustments should be discouraged. An increase of 4°F (such as from 78°F to 82°F) could increase energy consumption by as much as 40 percent.

Filter system--the time clock for operating the filter system should be set to operate the filter system for the minimum number of hours of operation required to maintain clean and healthful pool water.

Pool cover--it is recommended that the pool be covered except when the pool is in use. Use of the cover can cut pool heating costs by as much as 70 percent.

) **Pump Operation.**

Circulating hot water systems shall be arranged so that the circulating p(s) can be conveniently turned off, automatically or manually, when the hot water system is not in operation.

(d) **Pipe Insulation for Recirculating Systems.**

All recirculating system piping installed to serve buildings (and within) shall be thermally insulated in accordance with Section 422.

(e) **Showers.**

Showers used for other than safety reasons shall be equipped with flow control devices to limit total flow to a maximum of 3 gpm per shower head.

(f) **Water Heaters.**

Gas, oil-fired water heaters, and electric storage water heaters must meet the requirements of ASHRAE Standards 90A-80, and be so labeled.

All electric water heaters in unheated spaces shall he placed on an incompressible, insulated surface with a minimum thermal resistance of R-10. Electric water heaters placed on floors insulated to a minimum of R-10 shall be deemed to meet with this requirement.

604. LOW-RISE RESIDENTIAL BUILDING ELECTRICAL POWER AND LIGHTING.

The electrical power distribution and lighting systems shall conform to the requirements of section 424, et seq.

EXCEPTION: One and Two-family detached dwellings and the dwelling portion of multifamily buildings are exempt from the requirements of this section.

605. BUILDING ENVELOPE REQUIREMENTS FOR OTHER THAN LOW-RISE RESIDENTIAL BUILDINGS.

(a) **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 No. 6-5. Roof/ceilings enclosing mechanically cooled spaces shall be insulated to not less than tne nominal R value specified for roof/ceilings in Table No. 6-5. 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.

Installation of materials shall comply with Section 402 (d) and (e). In addition, below grade wall insulation shall extend from the top of the wall to the top of the footing or floor slab. Slab on grade floor insulation shall be installed along the entire perimeter of slab on grade floors, except for any part of slab which extends into an unconditioned space such as a garage, and shall extend downward from the top of the slab to the top of the footing or to the bottom of the thickened edge of a monolithic slab or for a minimum distance of 24 inches or downward to the bottom of the slab then horizontally beneath the slab for a minimum total distance of 24 inches and shall be an approved type.

(b) **Glazing Criteria.** All glazing shall be, at a minimum, double glazing. Insulating glass with at least 1/4 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 No. 6-5.

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.

(c) **Air Leakage.** All buildings shall comply with the air leakage requirement of Section 405.

606. BUILDING MECHANICAL SYSTEMS REQUIREMENTS FOR OTHER THAN LOW-RISE RESIDENTIAL BUILDINGS.

All building mechanical systems shall comply with the requirements of Sections 406 to 418, inclusive.

607. SERVICE WATER HEATING REQUIREMENT FOR OTHER THAN LOW-RISE RESIDENTIAL BUILDINGS.

All service water heating systems shall comply with the requirements of Sections 420 to 423, inclusive.

608. ELECTRICAL POWER AND LIGHTING REQUIREMENTS FOR OTHER THAN LOW-RISE RESIDENTIAL BUILDINGS.

All electrical power and lighting systems shall comply with the requirements of Sections 424 to 426, inclusive.

TABLE 6-1
LOW-RISE RESIDENTIAL BUILDINGS
MINIMUM (AVERAGE) ALLOWED R VALUES[1]

SPACE HEAT TYPE	CLIMATIC ZONE	CEILINGS[2]	ROOF DECKS	WALLS	FLOORS	SLAB ON GRADE[3]
Electric Resistance	I	38	38	19	19	8
Electric, Passive Solar	I	30	30	19	19	8
Other	I	30	30	19	19	8
Other, Passive Solar	I	30	30	19	19	8
Electric Resistance	II	38	38	19	25	10
Electric, Passive Solar	II	30	30	19	19	10
Other	II	30	30	19	19	10
Other, Passive Solar	II	30	30	19	19	10

[1]R values, except for walls, are for installed insulation material only.
[2]R-30 in single rafter, joist vaulted ceilings.
[3]Insulation shall be water-resistant material manufactured for this use.

TABLE 6-2
LOW-RISE RESIDENTIAL BUILDINGS
CLASSES OF GLAZING

CLASS	U-VALUE	WINDOW THERMAL TESTING REQUIREMENT[1]
90	.90	Untested
90	Greater than .75	Tested
75	.61 to .75	Tested
60	Less than .61	Tested

[1]See DEFINITIONS, Section 223. WINDOW THERMAL TESTING.

TABLE 6-3
LOW-RISE RESIDENTIAL BUILDINGS
HEAT PUMP MINIMUM EFFICIENCIES

SOURCE AND OUTDOOR TEMPERATURE (°F)	CLASS 1 COP	CLASS 1 HSPF	CLASS 2 COP	CLASS 2 HSPF
Air Source - 47 dB/43 WB	2.7		2.5	
Air Source - 17 dB/15 WB	1.8		1.5	
Air Source		6.35		5.60
Water Source - 60 entering	3.0		2.5	
Ground Source	3.0		3.0	

TABLE 6-4
LOW-RISE RESIDENTIAL BUILDINGS
GLAZING AND FURNACE
EFFICIENCY REQUIREMENTS

SPACE HEAT TYPE	CLIMATIC ZONE	MAXIMUM PERCENTAGE OF FLOOR AREA IN GLAZING	GLAZING CLASS	AFUE*	HEAT PUMP CLASS
Electric Resistance	I	21%	60	n/a	n/a
Electric, Passive Solar	I	21%	60	n/a	n/a
Other	I	21%	75	.65	2
Other	I	21%	90	.74	1
Other, Passive Solar	I	21%	90	.65	2
Electric Resistance	II	17%	60	n/a	n/a
Electric, Passive Solar	II	17%	60	n/a	n/a
Other	II	17%	75	.65	2
Other	II	17%	90	.74	1
Other, Passive Solar	II	17%	90	.65	2

*AFUE applies only to central heating equipment. All other types of heating equipment fueled by gas, oil, or propane must be equipped with an intermittent ignition device in order to use Class 90 glazing.

TABLE NO. 6-5
ALL OTHER THAN LOW-RISE RESIDENTIAL BUILDINGS
COMPONENT REQUIREMENTS

COMPONENT	ZONE I	ZONE II
Space Conditioning System Type	Any	Any
Opaque Envelope Minimum Nominal R Value		
Roof/Ceilings	R-30	R-30
Exterior Walls	R-11	R-11
Floors over Unconditioned Space	R-11	R-11
Below Grade Walls[1]	R-4	R-5
Slab on Grade Floors[1]	R-8	R-10
Glazing		
Type	Double	Double
Maximum Tot (Percent Exterior	32%	22%

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