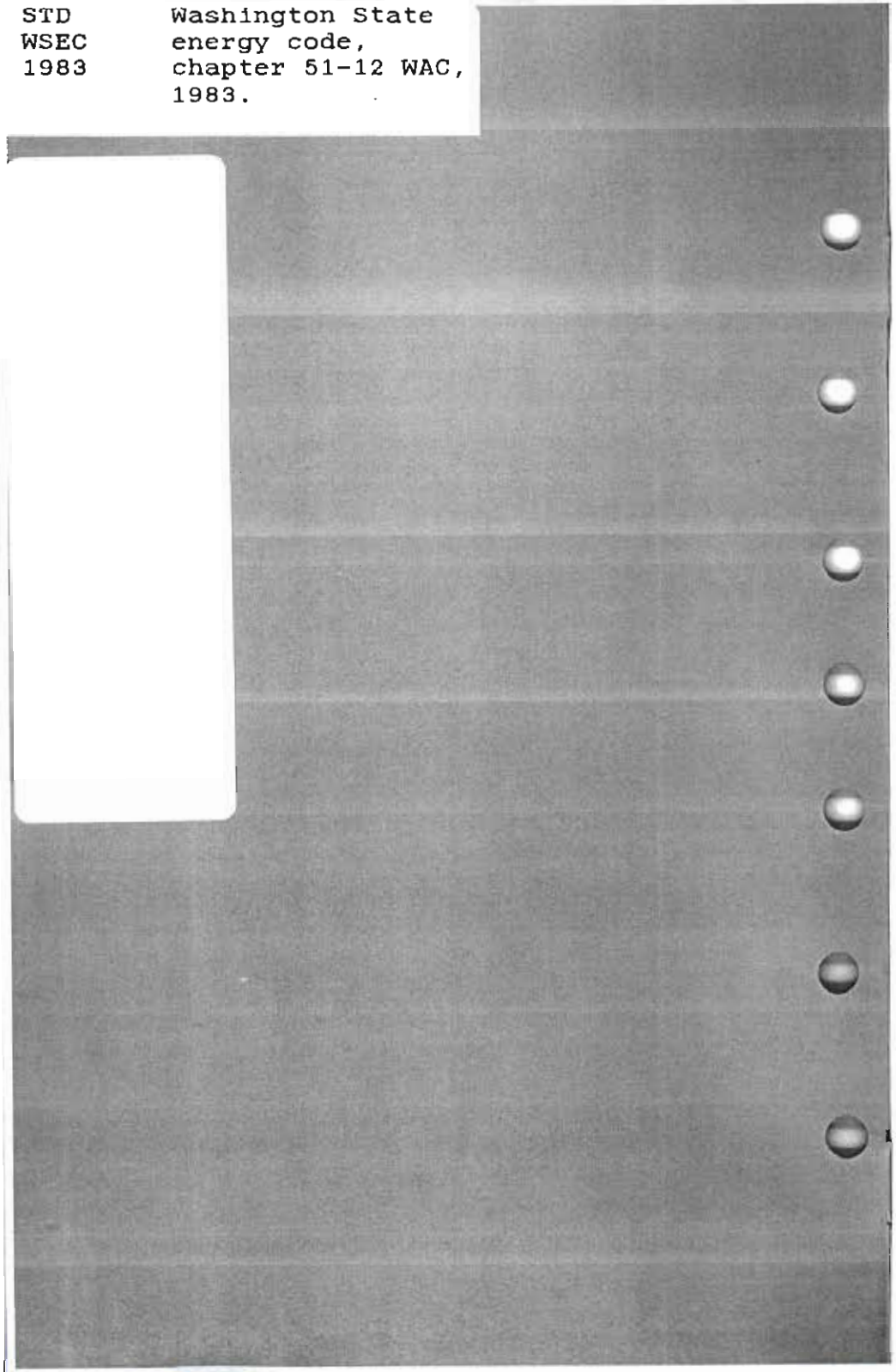


WAOENG-84-02

WASHINGTON STATE ENERGY CODE

Chapter 51-12 WAC

Adopted by the
STATE BUILDING CODE ADVISORY COUNCIL
Effective Date: November 10, 1983

Produced by:
Planning and Community Affairs Agency
Pat Dunn, Acting Director

and

Washington State Energy Office
Richard H. Watson, Director

John Spellman, Governor

STATE PRINTING PLANT 3 OLYMPIA, WASHINGTON

First Edition, August, 1980
Second Edition, March, 1984

Preface

This is the Washington Energy Code, Chapter 51-12 WAC. It is designed to provide complete requirements for energy efficiency of commercial and residential buildings.

The State of Washington has agreed to comply with the requirements of the State Energy Conservation Program as enacted in the federal Energy Policy and Conservation Act. Specifically, the State of Washington has agreed to implement thermal and lighting efficiency standards no less stringent than the ASHRAE 90-75 standards.

To comply with this requirement, the 1979 Legislature required the State Building Code Advisory Council (SBCAC) to adopt standards equivalent to ASHRAE 90-75 that would be in place by June 30, 1980.

The State Building Code Advisory Council and its Energy Code Committee solicited input and developed drafts for comment. In addition, a technical review panel was established to review the proposed draft of the code. While the technical review panel reviewed the code, the Building Code Advisory Council held a series of public hearings on the final draft code. The SBCAC formally adopted the energy code at a meeting on May 12, 1980.

Amendments adopted by the SBCAC on July 20, 1983, are incorported into this edition. These amendments were filed with the State Code Reviser on October 10, 1983, and became effective November 10, 1983.

WASHINGTON STATE ENERGY CODE
Table of Contents

Chapter 1
ADMINISTRATION AND ENFORCEMENT
Scope and General Requirements

Section 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."

Section 101. INTENT.

The purpose of this Code is to provide minimum standards for new 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.

Section 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, merchantile, 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.

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.

(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. Existing buildings that are substantially remodeled or rehabilitated (see definitions) shall conform to the provisions of this Code.

2. Historic Buildings. Historic buildings are exempt from this Code. This exemption shall apply to those buildings which have been specifically designated as historically significant by the state or local governing body, or listed in "The National Register of Historic Places" or which have been determined to be eligible for listing.

Section 103.

In addition to the requirement of this Code, buildings must conform to the provisions included in the State Building Code (RCW 19.27). In case of conflicts under the Uniform Building, Plumbing, or Mechanical Code; the provisions of this Code shall govern.

Section 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.

Section 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.

Section 106. PLANS AND SPECIFICATIONS.

(a) General. With each application for a building permit, and when required by the Building Official, plans and specifications shall be submitted. The Building Official may require plans and specifications be prepared by an engineer or architect licensed to practice by the state. All designs submitted under the provisions of Chapter 5 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 the 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.

Section 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. The Building Official is authorized and directed to enforce this Code. The Building Official is 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.

Section 108. VALIDITY.

If any section, subsection, sentence, clause, or phrase of this Code is, for any reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this Code.

Section 109. VIOLATIONS.

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

Section 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.

Section 111. ANNUAL REVIEW.

The State Building Code Advisory Council hereby intends to conduct an annual review of these energy code requirements and to make such changes and improvements as are deemed appropriate. (RCW 34.04.) The Council recognizes the authority of the Washington State Legislature to revoke this rule-making authority in any future session.

Chapter 2
DEFINITIONS

Section 200. GENERAL.

For the purpose of this amendatory act, 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.

Section 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.

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.

Section 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.

Section 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.

Section 204. D.

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

Section 205. E.

ECONOMIZER CYCLE. A control sequence of a fan system that modulates the amount of outside air for the purpose of space cooling without using mechanical cooling.

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, 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).

Section 206. F.

FENESTRATION. Any light-transmitting opening in a building envelope, including glazing, interior and exterior shading devices, and integral sun control devices.

Section 207. G.

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

GLAZING, SPECIAL. (See SPECIAL GLAZING).

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:

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.

Section 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. 403 (b) 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.

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.

Section 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.

Section 210. J. (Reserved).

Section 211. K. (Reserved).

Section 212. L. (Reserved)

Section 213. M.

MANUAL. Capable of being operated by personal intervention.

Section 214. N.

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

NON-DEPLETABLE ENERGY SOURCES. 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. Neither natural gas, oil, coal, liquefied petroleum gas, nor any utility-supplied electricity shall be considered a non-depletable energy source.

Section 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.)

OVERALL THERMAL TRANSFER VALUE (OTTV). An overall coefficient of heat gain expressed in units of Btu per hour per square foot.

Section 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.

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).

Section 217. Q. (Reserved).

Section 218. R.

READILY ACCESSIBLE. Capable of being reached 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.

Section 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).

SHADING COEFFICIENT (SC). The ratio of the solar heat gain through a glazing system to that of an unshaded single-pane of 1/8 inch float window glass under the same set of conditions.

$$SC = \frac{\text{Solar Heat Gain of Fenestration}}{\text{Solar Heat Gain of 1/8 inch float}}$$

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.

SPECIAL GLAZING. Glazing which has a maximum "U" value of 0.65. Insulating glass with at least 1/4 inch air space or approved storm sash will be considered to provide the "U" value required. Sealed insulated glass shall be tested in accordance with Specification ASTM E-774 to a minimum class "C" in accordance with a nationally recognized certification program and shall be so labeled.

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.

Section 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.

Section 221. U.

U VALUE. See THERMAL TRANSMITTANCE.

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.

Section 222. V.

VENTILATION AIR. That portion of supply air which comes from outside (outdoors) in a controlled manner, plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. (See ASHRAE Standard 62-73).

Section 223. W X Y Z.

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

Section 300. GENERAL.

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

Section 301.

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

Section 302. CLIMATIC ZONES.

The following shall be used for calculations required under this Code. (See also Figure 3-1.) All areas above 7000 degree days shall comply with Zone V.

(a) **Zone I** consists of the following counties: San Juan, Skagit, Snohomish, King, Pierce, Thurston, Lewis, Skamania, Clark, Cowlitz, Wahkiakum, Pacific, Grays Harbor, Mason, Kitsap, Jefferson, Island and Clallam.

(b) **Zone II** consists of the following counties: Klickitat, Benton, Franklin, Walla Walla, Columbia, Garfield, Asotin and Whatcom.

(c) **Zone III** consists of the following counties: Chelan, Douglas, Grant, Kittitas and Yakima.

(d) **Zone IV** consists of tbe following counties: Lincoln, Spokane, Adams and Whitman.

(e) **Zone V** consists of the following counties: Okanogan, Ferry, Stevens and Pend Oreille.

Section 303.

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

Section 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.)

Section 305. VENTILATION.

The ventilation air quantities for each type of occupancy shall be taken from ASHRAE Standard 62-73, "Natural and Mechanical Ventilation."

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.

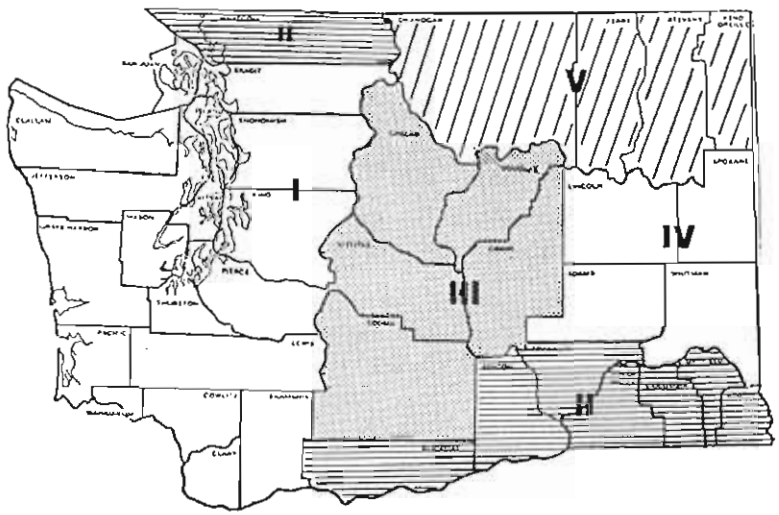
EXCEPTIONS: If outdoor air quantities other than those specified in ASHRAE Standard 62-73 are used or required because of special occupancy or process requirements, source control or air contamination, or other standards, the required outdoor quantities shall be used as the basis for calculating the heating and cooling design loads.

Where a conflict in ventilation requirements between this Code and the Uniform Building Code of 1979 occur, the former shall govern.

Section 306. METHODS OF COMPLIANCE.

Buildings or structures which are subject to this Code may satisfy their requirements either by application of a component performance approach (Chapter 4), a system analysis approach (Chapter 5), and in the case of low rise residential buildings and other buildings and structures containing less than 5,000 square feet of gross floor area, a prescriptive requirements approach (Chapter 6).

Figure 3-1
CLIMATIC ZONE MAP



Note: Climatic Zones* are based on a combination of heating degree days and design-outdoor temperatures; therefore, some local deviation may be necessary to reflect actual conditions. The local jurisdiction may authorize an adjacent Zone for application of energy code requirements in areas where local design conditions and degree days justify such a consideration. The adoption of a specific climatic zone shall be designated as part of the Ordinance adopted by the local governing body.

* All areas above 7,000 degree days shall comply with Zone V.

Chapter 4
BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH
(Standard Design)

Section 400. GENERAL.

The criteria of this Chapter establish the minimum requirements for thermal design of the exterior envelope of buildings (see Table 4-1) and for HVAC systems and its parts.

Section 401. (Reserved)

Section 402. OVERALL THERMAL PERFORMANCE.

(a) The stated U_0 value of any one element of a building, such as roof/ceiling, wall or floor, may be increased and the U_0 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_0 values.

(b) Where return air ceiling plenums are 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) Exemption for Passive solar Features.

Glazing areas which meet all of the following criteria may be exempted from the U_0 calculations:

1. The glazing area must have a thermal transmittance (U) value of not greater than .65.
2. Glazing must be oriented within 30° of due south. If it is mounted other than vertically, it must be tilted at least 30° up from the horizontal to face south.
3. The glazing must be clear. (Transmission coefficient numerically greater than or equal to .80 for the glazing itself).
4. The glazing must receive direct solar exposure for 50 percent of the hours between 9:00 a.m. and 3:00 p.m. on December 21.
5. The glazing must receive direct solar exposure for 85 percent of the hours between 9:00 a.m. and 3:00 p.m. on March 21.
6. For each square foot of exempt glazing, the building must contain a heat storage capacity equivalent to 75 Btu/day, located inside the insulated shell of the structure, and not covered with insulation materials such as carpet yielding an "R" value of 1.0 or greater.

Heat storage capacity shall be calculated by the following procedure:

HS = (WM) (SH) (T).

Where:

HS = Heat Storage Capacity (Btu/day).

WM = The weight of the materials (lbs.) inside the insulated shell of the building to a depth yielding a resistance of R-1, except in the case of slab floors where only the slab itself is credited.

SH = Specific Heat of those materials (Btu/lb.) (°F).

T = Temperature Fluctuation; 10°F per day will be the maximum allowable for calculation purposes, except that light weight frame construction will be allowed to fluctuate 15°F per day.

(d) General insulation and vapor barriers shall be installed in accordance with sound building practices.

Section 403. THERMAL PERFORMANCE CRITERIA 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. Steady state U_W values for opaque wall sections may be corrected by multiplying by the appropriate M factor before the calculation of the U_O in Equation 2. U_O and U_W are specified in units of

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

(b) Floors over unheated spaces shall not exceed the U_O values given in Tables 4-2.

(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.

(d) Windows and doors and air leakage: (see Section 405).

Section 404. THERMAL PERFORMANCE CRITERIA FOR ALL OTHER OCCUPANCIES.

(a) Heating Criteria.

1. 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_O and U_W are specified in units of

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

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

3. 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.

4. Alternative Wall Allowance for Low Rise Non-Residential Occupancies.

   A. For non-residential 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:

      i. 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

      ii. 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.

B. 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 thermal 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 resistance 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.

(b) Cooling Criteria.

1. Walls: Any building that is mechanically cooled shall have an overall thermal transfer value (OTTV) for the gross area of exterior walls not exceeding the values shown in Table 4-5 in Btu/h/sq. ft. Equation 3 of this section shall be used to determine acceptable combinations to meet these requirements.

2. Roof/Ceiling: Any building that is mechanically cooled shall have a combined thermal transmittance value (U_O value) for roof/ceiling not to exceed that specified in Table 4-3 and 4-4.

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 assembly 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:

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

EQUATION 3

$$OTTV = \frac{(U_W A_W TD_{EQ}) + (A_f SFSC) + (U_f A_f dt)}{A}$$

Where:

OTTV = average or combined thermal transfer value in $\frac{\text{Btu}}{\text{hr. sq. ft.}}$

A = gross exterior wall.
U_W = U value of opaque wall (all elements).
A_W = opaque wall area.
U_f = U value of the fenestration area.
A_f = fenestration area.
TD_{EQ} = temperature difference value (from Table 4-7).
SC = shading coefficient of the fenestration (see definitions).
SF = (See table 4-6).
dt = temperature difference between exterior and interior design condition °F.

NOTE: Where more than one type of wall is used, the respective terms for those elements shall be expanded into sub elements, as:

$(U_{w1}A_{w1}TD_{EQ1}) + (U_{w2}A_{w2}TD_{EQ2}) + \ldots$ etc.

Section 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 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, and 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 and millwork shop made wooden sash 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) Required fire doors with a fire resistant rating over one (1) hour, and fire windows are exempt from this section.

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.

Section 407. CALCULATIONS 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 Section 3 shall apply for all computations.

HVAC equipment for low-rise residential buildings shall be sized no greater than 125 percent of the design load as calculated above. If the selected manufacturer does not provide equipment in the range of 115 percent to 125 percent of the design load, the next size larger than 125 percent may be used.

Section 408. INFILTRATION.

Infiltration for heating and cooling design loads shall be calculated using accepted engineering practice, and Section 405.

Section 409. SIMULTANEOUS HEATING AND COOLING.

Simultaneous heating and cooling by reheating or recooling supply air or by concurrent operation of independent heating and cooling systems serving a common zone shall be restricted as delineated below:

(a) Recovered and non-depletable energy, provided the new energy expended in the recovery process is less than the amount recovered, may be used for control of temperature and humidity.

(b) New energy may be used for control of temperature if minimized as delineated in paragraphs (c) through (g).

(c) Reheat Systems. Systems employing reheat and serving multiple zones shall be provided with control that will automatically reset the system cold air supply to the highest temperature level that will satisfy the individual thermostat or primary zone requiring the coolest air. Single zone reheat systems shall be controlled to sequence heating and cooling. The total installed capacity of all reheat using new energy shall be limited to 15 percent of the total system design cooling capacity.

(d) Dual Duct and Multi Zone Systems. These systems shall be provided with control that will automatically reset: (1) the cold deck air supply to the highest temperature that will satisfy the zone requiring the coolest air, and (2) the hot deck air supply to the lowest temperature that will satisfy the zone requiring the warmest air.

Primary zone temperature and/or flow volume may be used as the control for this section. Primary zone is defined as an area with a single weather exposure and similar thermal loading.

The systems must be provided with heat pumps or recovery devices so that new energy is not required on the hot and cold deck or plenum simultaneously with the exception of limited warm-up periods.

(e) Recooling Systems: Systems in which heated air is recooled, directly or indirectly, to maintain space temperature shall be provided with control that will automatically reset the temperature to which the supply air is heated to the lowest and/or optimum level that will satisfy the zone requiring the warmest air. The system design shall limit the use of new energy for recooling of heated air to 15 percent of the total system heating capacity.

(f) A multiple zone HVAC system that employs reheating or recooling for control of not more than 5,000/ft. 3/min., or 20 percent of the total supply air for the building, whichever is less, shall be exempt from the supply air temperature reset requirement of paragraphs (c) through (g).

(g) Concurrent operation of independent heating and cooling systems serving common spaces and requiring the use of new energy for heating or cooling shall be minimized by one or both of the following:

1. By providing sequential temperature control of both heating and cooling capacity in each zone.
2. By limiting the heating energy input through automatic reset control of the heating medium temperature (or energy input rate) to only that necessary to offset heat loss due to transmission and infiltration and, where applicable, to beat the ventilation air supply to the space.

Section 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.)

Section 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 except single unit through-the-wall type heat pumps shall be exempt from low temperature requirements; units less than 15,000 Btu/hr at 47°DB shall have a minimum COP of 2.00.

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 gas and oil fired central heating plants shall show a minimum combustion efficiency of 75 percent at maximum rated output. Gas and oil fired room and space heaters shall show a minimum combustion efficiency of 70 percent at maximum rated output. Combustion efficiency is defined as 100 percent minus stack losses in percent of heat input. Stack losses are:

1. Loss due to sensible heat in dry flue gas;
2. Loss due to incomplete combustion;
3. Loss due to sensible and latent heat in moisture formed by combustion of hydrogen in the fuel. Central heating plant vents must be equipped with an approved automatic damper, where conditioned air is used for combustion.

(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 new heat renewal 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.

Section 412. ENERGY FOR AIR DELIVERY.

The air transport factor for non-residential all-air HVAC systems shall not be less than 5.0. 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.

Section 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.

Section 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.

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.

Section 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 up to 10°F between full heating and full cooling, except as allowed in Section 409(g).

(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. Multi-Family Dwellings: For multi-family 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 thedxterior 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 Multi-Family 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.

B. Other Buildings and Occupancies: Each HVAC system shall be equipped with a readily accessible or 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. Manual devices for use by operating personnel.

iii. Automatic control systems.

Section 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.

Section 417. DUCT CONSTRUCTION.

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

Section 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.

Section 419. (Reserved)

Section 420. WATER HEATERS, STORAGE TANKS, BOILERS, AND PIPING (when installed in non-conditioned spaces).

(a) Performance Efficiency.

1. Gas, oil fired water heaters and electric storage water heaters meeting the requirements of ASHRAE standards 90.75 and so labeled shall be deemed as satisfying the requirements of this subsection.

(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. Shut down: 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 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.

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

Section 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.

Section 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.

Section 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.

Section 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.

Section 425. ELECTRICAL DISTRIBUTION.

(a) Lighting Switching. Switching for building lighting systems shall be installed to control the operation of the lighting systems. The following mandatory requirements represent the minimum lighting controls to be installed in any building.

(b) General: All lighting controls except automatic controls shall be installed so as to be readily accessible.

EXCEPTION: Automatic controls, key controls, special controls, such as theatre lighting, places of assembly, etc.

Section 426. LIGHTING POWER BUDGET.

A lighting power budget is the upper limit to provide the lighting needs in accordance with the criteria and calculation procedure specified herein.

The lighting power budget for the 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 multi-family buildings are exempt from the requirements of this Section.

(a) The installed lighting wattage in the building shall not exceed the budget level calculated in this section. The budget wattage level shall be the sum of the interior budget calculated in accordance with Section 426 (b) and the exterior budget calculated in accordance with Section 426 (c). Lighting wattage includes lamp and ballast wattage.

(b) The interior lighting budget shall be calculated by multiplying the gross building area in square feet by the appropriate unit power budget, in watts per square foot, specified in Table 4-18.

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. 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.

(c) The exterior lighting budget shall be calculated by multiplying the building perimeter in feet by 7.5 watts per foot. An allowance for outdoor parking lighting may be added at 0.05 watts per square foot of parking area.

(d) Lighting for the following applications shall be exempted from inclusion in the calculation of this section when approved by the Building Official.

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

5. For Class I, II, and III retail occupancies as defined in Table 4-18 lighting for highlighting applications may be exempted from inclusion in the power budget up to the following limits:

Class I = 3.0 w/sq. ft.
Class II = 2.0 w/sq. ft.
Class III = 1.0 w/sq. ft.

TABLE 4-1
Classification of Building Occupancies

Residential	Non-Residential	
Other (Table 4-4)	(Table 4-4)	More than three stories.
Single family R-3 / Multi-family R-1 (Table 4-2)	(Table 4-3)	Three stories and less.

TABLE 4-2
Maximum Allowed U_O Values
Residential Occupanices
Buildings 3 Stories or Less

				Values for Perimeter Insulation				
Glazing[2]	Zone	Roofs Ceilings	Walls[1] (including glazing)	Floors	Heated Slab on Grade		Unheated Slab on Grade	
U		U_O	U_O	U_O	U_O	R	U_O	R
0.65	I	0.03	0.20	0.08	0.15	**6.35**	0.23	**4.25**
0.65	II	0.03	0.19	0.08	0.15	**6.35**	0.23	**4.25**
0.65	III	0.03	0.19	0.08	0.15	**6.35**	0.23	**4.25**
0.65	IV	0.03	0.18	0.08	0.12	**8.00**	0.19	**5.40**
0.65	V	0.03	0.15	0.05	0.12	**8.00**	0.19	**5.40**

1. In no case shall the average value of the opaque sections of frame or cavity wall be greater than U = 0.08.
2. All glazing must be special glazing, except that no more than 1 percent of the gross exterior wall may be single glazing for architectural, ornamental or security purposes.

TABLE 4-3

Maximum Allowed U Values
Non-Residential Occupancies
Buildings 3 Stories or Less

Zone	Ceilings	Walls	Floors	Heated Slab on Grade	Unheated Slab on Grade
I	0.05	0.25	0.08	0.15	0.23
II	0.05	0.25	0.08	0.15	0.23
III	0.05	0.25	0.08	0.15	0.23
IV	0.05	0.20	0.08	0.12	0.19
V	0.05	0.20	0.08	0.12	0.19

TABLE 4-4

Maximum Allowed U Values
All Occupancies
Buildings over 3 Stories

Zone	Ceilings	Walls	Floors	Heated Slab on Grade	Unheated Slab on Grade
I	0.09	0.30	0.08	0.15	0.23
II	0.08	0.30	0.08	0.15	0.23
III	0.08	0.30	0.08	0.15	0.23
IV	0.07	0.25	0.08	0.12	0.19
V	0.06	0.25	0.08	0.12	0.19

TABLE 4-5

All Buildings Other Than Low-Rise Residential

Cooling
Overall Thermal Transfer Values
(OTTV) — Walls

Degree North Latitude	OTTV= Btu/h Ft^2
46	35.0
47	35.0
48	36.0
49	36.0

Note: Equation 3 shall be used to determine acceptable combinations to meet the above requirements.

TABLE 4-6

All Buildings Other Than Low-Rise Residential

Degree North Latitude	Solar Factor Btu/h. Ft^2
46	134.0
47	135.0
48	136.0
49	137.0

Note: Use the Equation 3.

TABLE 4-7

Factors For Use With Equations 2 and 3

WALLS

Weight of Construction Lbs./$ft.^2$	TD_{EQ} Factor
0-25	44
26-40	37
41-70	30
71 and above	23

TABLE 4-8

Allowable Air Infiltration Rates

Windows	Residential Doors		Commercial Doors
(cfm per lineal foot of operable sash crack	cfm per lin. ft. of crack		cfm per lin. ft. of crack
	sliding glass	entrance	swinging, sliding, revolving
0.5	0.5	1.00	11.0

TABLE 4-9

HVAC System Heating Equipment (Heat Pumps)
Standard Rating Conditions

Conditions	Type	Air Source		Water Source
Air entering equipment	F	70 db	70 db	70 db
Outdoor unit ambient	F	47 db/ 43 wb	17 db/ 15 wb	—
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 temperature		F	44	44
Entering chilled water temperature		F	54	54
Leaving condenser water temperature		F	95	—
Entering water temp.		F	85	—
Non-ferrous tubes		*	0.0005	0.0005
Fouling factor, water steel tubes		*	0.0010	0.0010
Fouling factor, refrigerant		*	0.0000	0.0000
Condenser ambient (air or evap. cooled)		F	95 db/75 wb	—
Compressor saturated	Water cooled (or evap. cooled)	F	—	105
Discharge temp.	Air cooled	F	—	120

Standard ratings are at sea level.
* h ft² F/Btu.

TABLE 4-12

HVAC-System Heating Equiment (Heat Pumps)
Minimum COP

Source and Outdoor Temperature (°F)	Minimum COP
Air source — 47 dB/43 WB	2.5
Air source — 17 dB/15 WB	1.5
Water source — 60 entering	2.5
Ground source	3.0

See note following Table 4-14 and exception on Section 4-11 (b).

TABLE 4-13
Minimum EER and COP-Cooling

Standard Rating Capacity	EER	COP
Under 65,000 Btu/hr (19,050 watts)	6.8	2.0
65,000 Btu/hr (19,060 watts) and over	7.5	2.2

See note following Table 4-14.

TABLE 4-14
Applied HVAC System Components, Electrically Driven Water Chillers, and Compressor and Condenser Units — Minimum EER and COP-Cooling

Component	Condensing Means	Air		Water		Evap.	
		EER	COP	EER	COP	EER	COP
Self-contained Water chillers	Centrifugal	7.8	2.3	13.6	4.0		
	Positive Displacement	7.5	2.2	11.6	3.4		
Condenserless Water chillers	Positive Displacement	9.5	2.8	11.6	3.4		
Compressor & Condenser units 65,000 Btu/hr (19,050 watts and over)	Positive Displacement	8.5	2.5	11.9	3.5	11.9	3.5

Note: When tested at the standard rating conditions specified in Table 4-9, 4-10, 4-11.

TABLE 4-15
HVAC-System Heat-Operated Cooling Equipment

$$\text{Minimum COP} = \frac{\text{Net Cooling Output}}{\text{Total Heat Input (Electrical Auxiliary Inputs Excluded)}}$$

Heat Source	Minimum COP
Direct fired (gas, oil)	0.48
Indirect fired (steam, hot water)	0.68

TABLE 4-16
Insulation of Ducts

Duct Location	Insulation Types Mechanically Cooled	Heating Zone[3]	Insulation Types Heating Only
On roof or on exterior of building	C, V[2] and W	I	A and W
		II	B and W
		III	C and W
Attics, garages and crawl spaces	A and V[2]	I	A
		II	A
		III	B
In walls[1], within floor-ceiling spaces[1]	A and V[2]	I	A
		II	A
		III	B
Witbin the conditioned space or in basements	None Required		None Required
Cement slab or within ground	None Required		None Required

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 botb 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.

[3] Heating degree days:
Zone I — below 4500 D.D.
Zone II — 4501 to 8000 D.D.
Zone III — over 8001 D.D.

INSULATION TYPES:

A. 1-inch 0.60 lb/cu. ft. mineral fiber blankets and felt, rock, slag, or glass
1/2-inch 1.5 to 3 lb/cu. ft. blanket duct liner, rock, slag, or glass
1/2-inch 3 to 10 lb/cu. ft. board, mineral fiber, rock, slag, or glass,
or equivalent to provide an installed conductance = 0.48

B. 2-inch 0.60 lb/cu. ft. mineral fiber blanket
1-inch 1.5 to 3 lb/cu. ft. mineral fiber blanket (duct liner)
1-inch 3 to 10 lb/cu. ft. mineral fiber board
or equivalent to provide an installed conductance = 0.24

C. 3-inch 0.60 lb/cu. ft. mineral fiber blanket
1-1/2-inch 1.5 to 3 lb/cu. ft. mineral blanket (duct liner)
1-1/2-inch 3 to 10 lb/cu. ft. mineral fiber board
or equivalent to provide an installed conductance = 0.16

V. Vapor barrier, with perm rating not greater than 0.5 perms, 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: Run-outs up to 2"	1" and less	1¼" to 2"	2½" to 4"	5" to 6"	8" and larger
HEATING SYSTEMS							
Steam and hot water							
High pressure/ temperature	306-450	1½	1½	2	2½	3½	3½
Med. pressure/ temperature	251-305	1½	1½	2	2½	3	3
Low pressure/ temperature	201-205	1	1	1½	1½	2	2
Low temperature	120-200	½	1	1	1	1	1½
Steam condensate (for feed water)	Any	1	1	1	1½	1½	2
COOLING SYSTEMS							
Chilled water	40-55	½	½	3/4	1	1	1
Refrigerant, or brine	Below 40	1	1	1½	1½	1½	1½

TABLE 4-18
Interior Lighting Budget

Occupancy Type*	Lighting Power Budget — (watts/sq. ft.)
Auditoriums, theatres, public assembly	1.1
Hospitals	2.0
Indoor parking	0.3
Libraries	2.0
Offices	2.0
Restaurants	1.85
Retail Stores and Museums	
Class I (less than 1,000 sq. ft.)	3.0
Class II (1,000 to 6,000 sq. ft.)	2.75
Class III (6,000 to 20,000 sq. ft.)	2.6
Class IV (20,000 to 40,000 sq. ft.)	2.5
Class V (over 40,000 sq. ft.)	2.35
Schools	2.0
Warehouses	0.7

* In the case of an occupancy type not specifically mentioned above, the lighting power budget in watts per square foot shall be determined by the building official based on the most comparable occupancy type.

Chapter 5
BUILDING DESIGN BY SYSTEMS ANALYSIS AND BUILDING UTILIZING NON-DEPLETABLE ENERGY SOURCES

Section 500. GENERAL.

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

Section 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(c) (lighting switching).

Section 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 comparison of total energy usage shall be expressed in Btu 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.

Section 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.

Section 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.

Section 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.

Section 506. BUILDINGS UTILIZING NON-DEPLETABLE ENERGY.

(a) Buildings utilizing solar, geothermal, wind or other non-depletable 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 non-depletable source may be excluded from the total annual energy consumption attributed to the alternate design building by this chapter.

(b) To qualify for this exclusion, such non-depletable energy must be derived from a specific collection, storage and distribution system.

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

(d) All other criteria covered in this chapter and Chapter 4 shall apply to the proposed alternative designs utilizing non-depletable sources of energy.

Section 507. DOCUMENTATION — BUILDINGS USING NON-DEPLETABLE ENERGY SOURCES.

Proposes 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 non-depletable sources and the reduction in conventional energy requirements derived from nocturnal cooling shall be separately identified from the overall building energy use. Supporting documentation, on the basis of the performance estimates for the aforementioned non-depletable 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

Section 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 5000 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.

Section 601. BUILDING ENVELOPE REQUIREMENTS.

(a) Walls. The opaque exterior wall sections and the interior walls exposed to unheated spaces shall have a thermal resistance "R" value not less than the value specified in Table 6-1.

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

(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 12 inches below grade or frostline or 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 over heated basements, heated garages, or under floor areas used as plenums or in zones III, IV, and V where operable foundation vents are used. If 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. The area of skylights and the exterior windows sloped more than 30° from the vertical shall be doubled and this area shall be included in the percentage of the total glazing area as allowed for in Table 6-2.

Glazing meeting the criteria of part 2 of this sub-section (d) may be excluded from the calculation of glazed area.

2. Exemptions for Passive Solar Features.

   Glazing area which meets the following requirements may be excluded from the glazed area percentage calculation of part 1 of this subsection (d). The requirements establish criteria for solar access during the heating season, resistance to heat loss, and the provision of heat storage capacity within the insulated walls, either as part of a passive solar design or as part of the ordinary building floor, walls, or ceiling.

   A. The area must be double-glazed.

   B. The glazing must be oriented within 30 degrees of due south.

   C. The glazing must be untinted, non-reflecting glass.

   D. The glazing must receive direct solar exposure for 50 percent of the hours between 9:00 a.m. and 3:00 p.m. on December 21.

   E. The glazing must receive direct solar exposure for 85 percent of the hours between 9:00 a.m. and 3:00 p.m. on March 21.

   F. For each square foot of exempt glazing, the building must contain a heat storage capacity equivalent to 75 Btu/day, located inside the insulated shell of the structure, and not covered with insulation materials such as carpet yielding an "R" value of 1.0 or greater. Heat storage capacity is calculated as specified in Section 402 (c) 6.

   G. Compliance with all the requirements of section 402 (c) 6 will be taken as compliance with the above criteria for exempt glazing.

3. All skylights shall be double-glazed.

(e) Air Leakage.

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

   EXCEPTION: Required fire doors with a fire resistance rating over one (1) hour and fire windows 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) Vapor Barriers. A ground cover of 4 mil. (0.004") polyethylene or equivalent, lapped one foot at each joint and extended up the foundation wall to at least the outside ground line, is required at crawl spaces.

An approved vapor barrier shall be properly installed in roof decks, in enclosed rafter spaces formed where ceilings are applied directly to the underside of roof rafters and at exterior walls.

(g) General Insulation Requirements. Loose Fill. Blown or poured loose fill insulation may be used in attic spaces where the slope of the roof is not less than 2½ 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. Baffles shall be in place at the time of framing inspection.

Section 602. BUILDING MECHANICAL SYSTEMS — GENERAL.

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, for the specific type of device.

2. Combustion Heating Equipment. All gas and oil fired central comfort heating equipment shall show a minimum combustion efficiency of 75 percent at maximum rated output. Gas and oil fired room or space heaters shall show a minimum combustion efficiency of 70 percent at maximum rated output. Combustion efficiency is defined as 100 percent minus stack losses in percent of heat input. Stack losses are:

   A. Loss due to sensible heat in dry fuel gas.

   B. Loss due to incomplete combustion.

   C. Loss due to sensible and latent heat in moisture formed by combustion of hydrogen in fuel.

   Flues must be equipped with an approved automatic damper.

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 engi-

neering 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 125 percent of the design load as calculated above. If the selected manufacturer does not provide equipment in the range of 115 percent to 125 percent of the design load, the next size larger than 125 percent may be used.

All associated duct work shall be sized to meet air flow requirements as determined by the load calculation.

(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 multi-family dwellings, each individual dwelling unit shall he considered separately and shall meet the requirements of Section 602. Spaces other than living units shall meet the requirements of section 415 (c) 1.

3. Control Setback and Shutoff: Group R-1 and R-2.

   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 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.

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.

Section 603. 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 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 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.

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

(c) 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.

(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 Heater

Gas, oil fired water heaters, and electric storage water heaters must meet the requirements of ASHRAE standards 90.75, and be so labeled.

Section 604. 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 Multi-family buildings are exempt from the requirements of this section.

TABLE 6-1
Minimum (Average)[1] Allowed R-Values

Zone	Ceilings[2]	Roof Decks	Walls[3]	Floors	Heated Slab on Grade	Unheated Slab on Grade
I	30	30	11	11	6.35	4.25
II	30	30	11	11	6.35	4.25
III	30	30	11	11	6.35	4.25
IV	30	30	13	11	8.00	5.40
V	30	30	18	19	8.00	5.40

1. R-value is for installed insulation material only. Where insulation is installed in a continuous manner and is not interrupted by occasional framing members, its R-value may be increased by 20 percent in determining compliance with the requirements of this table. This allowance does not apply to insulation of slab on grade.
2. 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 erimeter to permit proper venting.
3. Concrete or masonry foundation walls of "unfinished basements" need not be insulated until finished, provided that any frame cripple walls shall comply with the insulation requirements of this table. Insulation installed shall comply with the requirements of this table.

TABLE 6-2
Maximum Percentage of Gross Exterior Wall Area in Glazing

Zone	Max. Percentage Glazing Area
I	21
II	19
III	19
IV	19
V	17

All glazing must be special glazing, except that no more than 1 percent of the gross exterior wall area may be single glazing for architectural or ornamental or security purposes.

Where walls contain glazing that is exempt under the passive solar provisions of Section 601(d)2, these maximum percentages shall apply to the remaining glass area on the basis of the gross exterior area of the remaining walls.

If the design glazing percentage is greater than the figure in the table, the calculation procedure of Section 403 must be used.