Energy code attachment [illegible]

September 14, 1989
0385H:SM:mls

INTRODUCED BY: North

PROPOSED NO. 89-744

ORDINANCE NO. 9190

AN ORDINANCE relating to the adoption of the 1987 edition of the Northwest Energy Code Standards, and other standards regulating the use of energy in buildings and structures in unincorporated King County, amending K.C.C. 16.04.050 and Ordinance 3647, Section 6 as amended.

PREAMBLE:
King County within the incorporated area of the county may adopt by reference recognized codes and their compilations relating to construction of buildings.

The adoption of energy codes which enable the effective use of electrical and other forms of heat in new building construction will provide for a more effective utilization of electrical energy and conserve other energy resources which would be in the best interest of the public.

The energy surplus in the Northwest is disappearing as the population increases and the economy expands. Energy efficiency will reduce the pressure for future rate increases and will stretch our current clean energy efficient resources into the future.

The Bonneville Power Administration Solicitation No. DE-PS79-89BP 93,000, entitled the Northwest Energy Code Program, includes reimbursement provisions for the administration and enforcement of the Northwest Energy Code regulating the use of electrical energy as well as some reimbursement of additional cost to the builder and consumer for conservation components attributable to compliance with the model conservation standards in order to encourage affordable housing for entry level consumers.

The council further finds that consumption of and efficient use of natural gas and oil is environmentally and economically sound public policy.

Therefore, the county finds it in the public interest to adopt the Northwest Energy Code.

BE IT ORDAINED BY THE COUNCIL OF KING COUNTY:

SECTION 1. K.C.C. 16.04.050 and Ordinance 3647, Section 6 as amended are hereby amended as follows:

The 1987 edition of the Northwest Energy Code regulating the use of electrical energy (as set forth in Attachment A attached the King County modifications to the 1985 editions of the Uniform Building Code, Uniform Mechanical Code, Uniform Housing Code, and Uniform Code for the Abatement of Dangerous Buildings are adopted as part of the code.

SECTION 2. The effective date shall be July 1, 1990, or when a contract providing for reimbursement as set forth in the Northwest Energy Program can be successfully negotiated with the Bonneville Power Administration whichever is later.

SECTION 3. Notwithstanding the implementation of the Northwest Energy Code regulating electrically space-heated construction, the 1986 State Energy Code (second edition) shall continue to apply to all non-electrically space-heated residentia and non-residential construction provided that:

A. New residential buildings which are space-heated with all other forms of space heating not covered by the Northwest Energy Code, shall be designed to achieve energy use equivalent to energy use achieved in typical buildings constructed with:

1. Ceiling insulated to a level of R-30 (R value includes insulation only);

2. Walls insulated to a level of R-19 (R value includes insulation only), or constructed with two by four members, R-13 insulation batts, R-3.2 sheathing, and other normal assembly components;

3. Below grade walls, insulated on the interior side, to a level of R-19 (R value includes insulation only), or if insulated on the exterior side, to a level of R-10;

4. Floors over unheated space insulated to a level of R-19 (R value includes insulation only);

5. Slab on grade floors insulated to a level of R-10 at the perimeter;

6. Heat pumps with a minimum heating season performance factor (HSPF) of 6.8 or with all other energy sources with a minimum annual fuel utilization efficiency (AFUE) of seventy-eight percent;

7. Double glazed windows with values not more than U-0.65; when tested per AAMA standard #1503.1 - 88; and

8. The maximum glazing area shall be twenty-one percent of the floor area. For purposes of determining equivalent thermal performance the maximum glazing area shall be fifteen percent of the floor area.

SECTION 4. The executive is authorized to negotiate a contract with Bonneville Power Administration to implement this ordinance.

INTRODUCED AND READ for the first time this 18th day of September, 19 89.

PASSED this 30th day of October, 1989.

KING COUNTY COUNCIL
KING COUNTY, WASHINGTON

[signature]
Chair

ATTEST:

[signature] J.B. Crawford II
Clerk of the Council

APPROVED this 7th day of November, 1989.

[signature]
King County Executive

# NORTHWEST ENERGY CODE

**(Complete Code Version)**

**JUNE 1987**

Amendments to the MODEL ENERGY
CODE to be equivalent to the
Model Conservation Standards

## SAMPLE ORDINANCE FOR ADOPTION OF THE

## NORTHWEST ENERGY CODE AND STANDARDS

## ORDINANCE NO._____

An ordinance of the ___(jurisdiction)___ adopting the 1987 edition of the Northwest Energy Code and the 1987 edition of the Northwest Energy Code Standards regulating the use of electrical energy in all buildings or structures in the ___(jurisdiction)___; providing for penalties for the violation thereof, repealing Ordinance No. ______ of the ___(jurisdiction)___ and all other ordinances and parts of the ordinances in conflict therewith.

The ___(governing body)___ of the ___(jurisdiction)___ does ordain as follows:

**Section 1.** That certain documents, three (3) copies of which are on file and are open for inspection of the public in the office of the ___(jurisdiction's keeper of records)___ of the ___jurisdiction___, being marked and designated as:

Northwest Energy Code 1987 edition, published by the Bonneville Power Administration and Standards listed in Chapter 8 of this specified Northwest Energy Code, including the Appendix Chapters _________. (Fill in the applicable Appendix chapters--see code section 103, last paragraph.)

**Section 2.** (Incorporate penalties for violations. See Section 205).

**Section 3.** That Ordinance No. _____ of ___(jurisdiction)___ entitled (fill in the title of building ordinance or ordinances in effect at the present time) and all other ordinances or parts of ordinances in conflict herewith are hereby repealed.

**Section 4.** That if any section, subsection, sentence, clause or phrase of this ordinance is, for any reason, held to be invalid or unconstitutional, such decision shall not affect the validity or constitutionality of the remaining portions of this ordinance. The ___(governing body)___ hereby declares that it would have passed this ordinance, and each section, subsection, clause or phrase hereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses and phrases be declared unconstitutional.

**Section 5.** That the ___(jurisdiction's keeper of records)___ is hereby ordered and directed to cause this ordinance to be published. (An additional provision may be required to direct the number of times the ordinance is to be published and to specify that it is to be in a newspaper in general circulation.

Posting may also be required.)

**Section 6.** That this ordinance and the rules, regulations, provisions, requirements, orders and matters established and adopted hereby shall take effect and be in full force and effect (time period) from and after the date of its final passage and adoption.

# FOREWORD

The development of this "Northwest Energy Code" which are amendments to the Model Energy Code, 1986 edition, was sponsored by the Bonneville Power Administration (BPA). Information on this document may be obtained from BPA, PO Box 3621, Portland, OR 97208.

This document contains amendments to the Council of American Building Officials' (CABO) Model Energy Code (MEC), 1986 Edition. A copy of the MEC can be obtained from CABO at 1201 One Skyline Place, 5205 Leesburg Pike, Falls Church, Virginia 22041, telephone (703)931-4533; International Conference of Building Officials (ICBO) 5360 South Workman Mill Road, Whittier, CA 90601; Northwest Regional Office ICBO, 12505 Bellevue-Redmond, Suite 208, Bellevue, WA 98005, telephone (206)451-9541;

This code has been designed to be as compatible as possible with state and local regulations and is intended to stand alone as a code for those who desire a complete energy code. For those who want a document designed as if it were a chapter in the "Uniform Building Code" a related document has been prepared by BPA and is available from the Northwest ICBO Office.

Symbols:

| | |
|---|---|
| ~~this text is~~: | this line-out means that the MEC language is deleted. |
| -->: | this arrow means that more than one deletion has been made. |
| ¦ | this is language developed by BPA. |

Where none of the above symbols occur, the text is exactly reprinted from the MEC.

# DISCLAIMER

The Bonneville Power Administration acknowledges that although these amendments use the same format as The Model Energy Code, 1986 edition, published and copyrighted by CABO, the technical requirements contained therein **ARE NOT THE SAME AS THE MODEL ENERGY CODE** and are **NOT** based on a national consensus. These amendments are designed to be used with and compatible with the Model Energy Code, 1986 edition. The provisions of this code do not consider the efficiency of various energy forms as they are delivered to the building envelope, i.e., delivered energy efficiency. The appropriate factor for delivered energy--efficiency should be considered prior to the selection of the mechanical, electrical, illumination systems, and energy form for specific uses. A determination of delivered energy efficiencies when used in conjunction with this code will provide the most efficient use of available energy in new building construction.

TABLE OF CONTENTS

CHAPTER

1 **ADMINISTRATION AND ENFORCEMENT**.................. 1
101. Scope and General Requirements............. 1
102. Materials and Equipment.................... 4
103. Alternate Materials--Method of Construction, Design or Insulating Systems............... 4
104. Plans and Specifications................... 5
105. Enforcement & Inspections...................6
106. Validity................................... 6
107. Violations................................. 7
108. Liability.................................. 7

2 **DEFINITIONS**...................................... 8
201. General Definitions........................ 8

3 **DESIGN CONDITIONS**................................ 20
301. Design Criteria............................ 20
302. Thermal Design Parameters.................. 20
303. Mechanical Ventilation Criteria............ 22

4 **BUILDING DESIGN BY SYSTEMS ANALYSIS ~~AND DESIGN OF BUILDINGS UTILIZING NONDEPLETABLE ENERGY SOURCES~~**........................................ 29
401. Scope...................................... 29
402. Systems Analysis........................... 29

5 **BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH**........................................ 34
501. Scope...................................... 34
502. Building Envelope Requirements............. 34
503. Building Mechanical Systems................ 43
504. Service Water Heating...................... 52
505. Electrical Power and Lighting.............. 55

6 **BUILDING DESIGN BY PRESCRIPTIVE REQUIREMENTS**.... 68
601. Scope...................................... 68
602. Building Envelope Requirements............. 68
603. Air Leakage................................ 71
604. Building Mechanical Systems................ 71

7 **BUILDING DESIGN BY COMPONENT POINT SYSTEM**....... 77
701. Scope...................................... 77
702. Calculation Procedure...................... 77

8 **STANDARDS**........................................ 85
Accredited Authoritative Agencies............... 87
NWEC Std #25. Ventilation System Installation.. 88
NWEC Std #26. Air-to-Air Heat Exchangers....... 110

-->


APPENDIX.................................... 114

10 OPTIONAL CALCULATION PROCEDURE FOR CONNECTED INTERIOR LIGHTING BUDGET ....................... 115

# CHAPTER 1

# ADMINISTRATION AND ENFORCEMENT

## SECTION 101

## SCOPE AND GENERAL REQUIREMENTS

### 101.1 Title

| This code shall be known as the Northwest Energy Code, and may | be cited as such. It is referred to herein as "this code".

### 101.2 Intent

The provisions of this code shall regulate the design of building envelopes for adequate thermal resistance and low air leakage and the design and selection of mechanical, electrical, service water heating and illumination systems and equipment which will enable effective use of electric energy in new building construction.

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

1. A systems approach for the entire building and its energy-using subsystems,Chapter 4; or

2. A component performance approach for various building elements and mechanical systems and components, Chapter 5; or

| 3. ~~Specified-acceptable--practice~~, A prescriptive requirements | approach, Chapter 6; or

| 4. A component point system approach, Chapter 7.

| Subject to the limits which apply to each Chapter compliance with any one of these paths meets the intent of this code. ~~This code-is-not-intended-to-abridge--safety,-health--or-environmental requirements-required-under-other-applicable-codes-or-ordinances.~~

| This code is intended to supplement the provisions of the | Uniform Building Code, the Uniform Mechanical Code, and the | National Electric Code, and in case of conflict between this code | and any of those codes with respect to the efficient use of | electricity, the provisions of those codes shall apply. In any

case where a Federal, state or local code or regulation exceeds this code's requirements with respect to securing more efficient use of electric energy, that code or regulation shall apply.

### 101.3 Scope

This code sets forth minimum requirements for the design of new buildings and structures or portions thereof and additions, alterations and repair to existing buildings that provide facilities or shelter for public assembly, educational, business, mercantile, institutional, storage and residential occupancies, as well as those portions of factory and industrial occupancies, designed primarily for human occupancy by regulating their exterior envelopes and the selection of their HVAC, service water heating, electrical distribution and illuminating systems and equipment for effective use of electric energy.

Buildings shall be designed to comply with the requirements of Chapter 4, 5, 6, or 7 of this code.

Wherever in this code reference is made to the appendix, the provisions in the appendix shall not apply unless specifically adopted.

**101.3.1 Exempt Buildings.** Buildings and structures or portions thereof meeting any of the following criteria shall be exempt from the building envelope requirements of Section 502, 602, and 702. However, the energy usage from all sources shall be included in any analysis performed pursuant to Chapter 4.

**101.3.1.1** Buildings and structures or portions thereof whose peak design rate of energy usage is less than 3.4 Btu/h per square foot or 1.0 watt per square foot of floor area for ~~all purposes~~ space conditioning requirements.

**101.3.1.2** Buildings and structures or portions thereof which are neither heated or cooled according to the definitions in Chapter 2, provided that any space heating equipment which is installed complies with all of the following criteria:

a. Sized for a maximum interior design temperature of less than 50 degrees F.
b. Equipped with thermostatic control which is manufactured to have a maximum temperature setting of 50°F or less

**101.3.2 Application to Existing Buildings.**

**101.3.2.1 Additions, alterations and repairs to existing buildings.** Additions, alterations and repairs may be made to existing buildings or structures ~~may be made to such buildings or~~

structures without making the entire building or structure comply provided that the new addition alteration or repair shall conform to the provisions of this code as they relate to new construction. ~~The Building Official may approve designs of alterations or repairs which do not fully conform with all of the requirements of this code where in his/her opinion full conformance is physically impossible and/or economically impractical and (1) the alteration or repair improves the electric energy efficiency of the building, or (2) the alteration or repair is energy efficient and is necessary for the health, safety, and welfare of the general public.~~ Where the structural elements of the altered portions of roof/ceiling, wall or floor are not being replaced, these elements shall be deemed to comply with this Code if all the cavities exposed during construction are filled to the full depth with batt insulation or insulation having an equivalent nominal R value while for roof/ceiling, maintaining the required space for ventilation. Existing roof/ceilings, walls and floors without framing cavities need not be insulated.

**101.3.2.2 Lighting.** Those parts of lighting systems which are altered or replaced in buildings initially constructed to the requirements of this code shall comply with Section 505.4. In addition, other remodels or replacements which affect the lighting system of a floor shall also comply with the lighting power budgets specified in Section 505.3.

**101.3.2.3 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.

**101.3.2.4 Change of occupancy.** A change in the occupancy or use of an existing building or structure constructed under this code which would require an increase in demand for ~~either fossil fuel or~~ electrical energy supply shall not be permitted unless such building or structure is made to comply with the requirements of this code.

**101.3.2.5 Moved Buildings.** Buildings or structures moved into or within the jurisdiction shall comply with the envelope insulation provisions of this code for new buildings or structures when the cavities of the roof/ceiling, wall or floor elements are accessible or exposed & Sec 101.3.2.1 if it applies.

EXCEPTION: The ceiling cavity need not be filled to more than the full depth of the space available including adequate space for ventilation.

**101.3.3 Mixed Occupancy.** When a building houses more than one occupancy, each portion of the building shall conform to the requirements for the occupancy housed therein. Where minor accessory uses do not occupy more than 10 percent of the area of any floor of a building, the major use shall be considered the building occupancy.

## SECTION 102

## MATERIALS AND EQUIPMENT

### 102.1 Identification

Materials and equipment shall be identified in order to show compliance with this code.

### 102.2 Maintenance Information

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

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

### 103.1 Alternate Materials and Methods of Construction

The provisions of this code are not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been approved by the building official as meeting the intent of the code.

The building official may approve any such alternate, provided he finds that the proposed design is satisfactory and complies with the provisions of this code and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in suitability, strength, effectiveness, fire resistance, durability, safety and sanitation.

The building official shall require that sufficient evidence or proof be submitted to substantiate any claims that may be made regarding its use. The details of any action granting approval of an alternate shall be recorded and entered in the files of the code enforcement agency.

### 103.2 Tests

Whenever there is insufficient evidence of compliance with any of the provisions in this code or evidence that any material or construction does not conform to the requirements of this code, the building official may require tests as proof of compliance to be made at no expense to this jurisdiction.

Test methods shall be as specified by this code or by other recognized test standards. If there are no recognized and accepted test methods for the proposed alternate, the building official shall determine test procedures.

All tests shall be made by an approved agency. Reports of such tests shall be retained by the building official for the period required for the retention of public records.

### 103.3 Board of Appeals

In order to determine the suitability of alternate materials and methods of construction and to provide for reasonable interpretations of this code, there shall be and is hereby created a Board of Appeals consisting of members who are qualified by experience and training to pass upon matters pertaining to building construction and who are not employees of the jurisdiction. The building official shall be an ex officio member of and shall act as secretary to said board. The Board of Appeals shall be appointed by the governing body and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business and shall render all decisions and findings in writing to the appellant with a duplicate copy to the building official.

## SECTION 104
## PLANS AND SPECIFICATIONS

### 104.1 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 to be prepared by an engineer or architect licensed to practice by the state. (Designs submitted under the provisions of Chapter 4 for other than low rise R-3 occupancies shall be prepared by an engineer or architect licensed to practice by the state.)

### 104.2 Details

The plans and specifications shall show in sufficient detail 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.

## SECTION 105

## ENFORCEMENT AND INSPECTIONS

### 105.1 General

Construction or work for which a permit is required shall be subject to inspection by the building official.

### 105.2 Approvals Required

No work shall be done on any part of the building or structure beyond the point indicated in each successive inspection without first obtaining the written approval of the building official. No construction shall be concealed without inspection approval.

### 105.3 Final Inspection

There shall be a final inspection and approval for buildings when completed and ready for occupancy.

### 105.4 Reinspection

The building official may cause a structure to be reinspected.

## SECTION 106

## VALIDITY

If a 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 107

## VIOLATIONS

It shall be unlawful for any person, firm or corporation to erect, construct, enlarge, alter, repair, move, improve, remove convert or demolish, equip, use, occupy or maintain any building or structure or cause or permit the same to done in violation of this code.

## SECTION 108

## LIABILITY

The building official, or his authorized representative charged with the enforcement of this code, acting in good faith and without malice in the discharge of his duties, shall not thereby render himself personally liable for any damage that may accrue to persons or property as a result of any act or by reason of any act or omission in the discharge of his duties. Any suit brought against the building official or employee because of such act or omission performed by him in the enforcement of any provision of such codes shall be defended by this jurisdiction until final termination of such proceedings, and any judgment resulting therefrom shall be assumed by this jurisdiction.

This code shall not be construed to relieve from or lessen the responsibility of any person owning, operating or controlling any building or structure for any damages to persons or property caused by defects, nor shall the code enforcement agency or its parent jurisdiction be held as assuming any such liability by reason of the inspections authorized by this code or any certificates of inspection issued under this code.

# CHAPTER 2

# DEFINITIONS

## SECTION 201

## GENERAL DEFINITIONS

### 201.1 Application of Terms

For the purposes of this code, certain abbreviations, terms, phrases, words and their derivatives, shall be as set forth in this chapter. Where terms are not defined, they shall have their ordinary accepted meanings within the context with which they are used. Webster's Third New International dictionary of the English Language, Unabridged, copyright 1981, shall be considered as providing ordinarily accepted meanings.

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

**ACCESSIBLE** (as applied to equipment). Admitting close approach because not guarded by locked doors, elevation or other effective means. (See **READILY ACCESSIBLE.**)

**ADVANCED FRAMING.** Framing techniques used to minimize the amount of uninsulated that is not required for proper structural support.

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

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

**AUTOMATIC.** Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature or mechanical configuration. (See **MANUAL.**)

**BELOW GRADE WALLS.** Walls or the portion of walls which extend two feet or more below the finish grade.

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

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

**BUILDING OFFICIAL.** The official authorized to act in behalf of the responsible government agency for the enforcement of this code.

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

**CLERESTORY.** A window placed in a wall projecting from a roof plane at sixty (60) degrees or more from the horizontal to admit daylight into the interior of a building. (See **Skylight.**)

-->

**COEFFICIENT OF PERFORMANCE (COP).** See the following paragraphs in Chapter 5 for the definitions of COP as appropriate:

Electrically Operated HVAC System Equipment--Cooling 503.4.5.2

Applied HVAC System Components--Cooling 503.4.6.1

-->

Heat Pump--Heating 503.4.2.2

-->

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

**CONDITIONED FLOOR AREA.** The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

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

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

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

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

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

-->

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

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

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

**ENERGY, RECOVERED.** (See **RECOVERED ENERGY.**)

-->

**EXTERIOR ENVELOPE.** (See **BUILDING ENVELOPE.**)

**FLOOR OVER UNCONDITIONED SPACE (ENCLOSED).** A floor which separates a conditioned space from an unconditioned space which is buffered from exterior ambient conditions including vented crawlspaces and unconditioned basements or other similar spaces.

**FLOOR OVER UNCONDITIONED SPACE (EXPOSED).** A floor which separates a conditioned space from an unconditioned space exposed to exterior ambient conditions including open parking garages and enclosed garages which are mechanically ventilated.

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

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

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

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

**GROSS EXTERIOR WALL AREA.** The normal projection of the building envelope wall area bounding interior space which is conditioned by an energy-using system; includes opaque wall, window and door areas.

The gross area of walls consists of all opaque wall areas, including foundation walls, between floor spandrels, peripheral edges of floors, window areas including sash, and door areas, where such surfaces are exposed to exterior ambient conditions and enclose a conditioned space including interstitial areas between two such spaces.

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

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

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

**HEATED SPACE.** Space within a building which is provided with a positive heat supply to maintain a temperature of greater than 50°F. Finished living space within a basement or registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space.

**HEATING SEASON PERFORMANCE FACTOR (HSPF).** The total heating output (in Btu) of a heat pump during its normal annual usage period for heating divided by the total (watt hour) electric power input during the same period, as determined by test procedures consistent with the U.S. Department of Energy "Test Procedure for Central Air Conditioners, Including Heat Pumps" published in the December 27, 1979, Federal Register, Vol 44, No. 24, IOCFR. 430. When specified in Btu per watt hour an HSPF of 6.826 is equivalent to an HSPF of 2.0 watt hour per watt hour.

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

**HVAC.** Heating, ventilating and air conditioning.

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

**HVAC SYSTEM EFFICIENCY.** (See **EFFICIENCY, HVAC SYSTEM.**)

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

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

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

| **LOW-RISE BUILDING.** A building not exceeding three stories in height.

-->

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

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

-->

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

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

**OPERABLE WINDOW INSULATION.** Movable window covers of insulating material which have means to create an edge fit better than a loose fit (i.e., interlocking edge, cushion seal, mechanical, or magnetic seal) and with a minimum thermal resistance of R-5.

-->

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

**PACKAGED TERMINAL AIR CONDITIONER.** A factory-selected combination of heating and cooling components, assemblies or sections intended to serve a room or zone. (For the complete technical definition, see Standard RS-10.)

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

**PERMEANCE** (perm). The ability of a material of specified thickness to transmit moisture in terms of amount of moisture transmitted per unit time for a specified area and differential pressure (grains per hour-ft$^2$-in.HG). Permeance may be measured using ASTM E-96-72 or other approved dry cup method as specified in RS-1.

**POSITIVE COOLING SUPPLY.** Mechanical cooling deliberately supplied to a space, such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space-cooling components, such as evaporator coil cases and cooling distribution systems which continually maintain air temperatures within the space of 85 degrees F or lower during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

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

**POSITIVE COOLING SUPPLY.** Mechanical cooling deliberately supplied to a space, such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space cooling components, such as evaporator coil cases and cooling distribution systems which continually maintain air temperatures within the space of 85 degrees F, or lower during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

**POSITIVE HEAT SUPPLY.** Heat deliberately supplied to a space by design, such as a supply register, radiator or heating element. Also, heat indirectly supplied to a space through uninsulated surfaces of service water heaters and space heating components, such as furnaces, boilers and heating and cooling distributions systems which continually maintain air temperature within the space of 50 degrees F or higher during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

**POWER.** The rate at which electric energy is transmitted; in customary units, measured in watts (W) or British thermal units per hour (Btu/h).

| **POWER FACTOR.** The ratio of the true power (watts) to the
| apparent power (volts times amperes), the cosine of the angle of
| lag between the alternating current and the voltage waves.

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

| **R-VALUE.** Thermal resistance as measured in degrees F-ft$^2$-
| hr/Btu. Nominal R-Value shall mean thermal resistance of
| insulation (excluding structural or sheathing components) as
| specified by the manufacturer according to recognized trade and
| engineering standards or approved equal.

**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.**)

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

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

-->

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

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

**ROOF/CEILING ASSEMBLY.** A roof/ceiling assembly shall be considered as all components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed exterior ambient conditions to and encloses a conditioned space.

The gross area of a roof/ceiling assembly consists of the total interior surface of such assembly, including skylights.

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

-->

**SEQUENCE.** A consecutive series of operations.

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

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

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

-->

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

**SHALL.** Denotes a mandatory code requirement.

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

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

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

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

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

**STANDARD FRAMING.** All framing practices not defined as "advanced" shall be considered standard.

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

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

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

**THERMAL CONDUCTANCE (C).** The thermal transmission in unit time through unit area of a particular body or assembly having defined surfaces when the unit average temperature is established between surfaces (Btu/hr ft$^2$ F).

**THERMAL RESISTANCE (R).** The reciprocal of thermal conductance (hr ft$^2$ F/Btu).

**THERMAL TRANSMITTANCE (U).** The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/hr-ft$_2$ °F). The U- value applies to the fractional combinations of different materials used in series along the heat flow path.

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

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

**U-VALUE.** See thermal transmittance.

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

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

**VAPOR RETARDER.** A layer of low moisture transmissivity material (not more than 1.0 perm dry cup) placed over the warm side (in winter) of insulation, over the exterior of below grade walls, and under floors as ground cover to limit the transport of water and water vapor through exterior walls, ceilings, and floors.

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

-->

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

**VENTILATION AIR.** That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. (See Table 3-1, Chapter 3 of this code, and definition of **OUTDOOR AIR.**)

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

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

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

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

-->

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

# CHAPTER 3

# DESIGN CONDITIONS

## SECTION 301 DESIGN CRITERIA

### 301.1 General

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

### 301.2 Heating and Cooling

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

The design shall not create conditions of accelerated deterioration from moisture condensation.

## SECTION 302

## THERMAL DESIGN PARAMETERS

### 302.1 Exterior Design Conditions

The following design parameters shall be used for calculations required under this code. (The Building Official is to fill in with applicable data.)

| EXTERIOR DESIGN CONDITIONS | | |
|---|---|---|
| WINTER[1] | Design Dry-bulb | °F |
| SUMMER[1] | Design Dry-bulb | °F |
| | Design Wet-bulb | °F |
| DEGREE DAYS HEATING | | |
| DEGREES NORTH LATITUDE | | |

The outdoor design temperature shall be selected from the columns of 97-1/2 % values for winter (99% values for Zone 3) and 2-1/2 % values for summer from tables in Standard RS-1. Adjustments may be made to reflect local climates as determined by the building official.

## 302.2 Interior Design Conditions

**302.2.1 Indoor Design Temperature.** Indoor design temperature shall be ~~72~~ 70 degrees F for heating and 78 degrees F for cooling.

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

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

**302.2.3 New Energy for Humidity Control.** New energy may be used to prevent relative humidity from rising above 60 percent for comfort control, to prevent condensation on terminal units or outlets, or to prevent the malfunctioning of special equipment.

**302.3.1 Heating and Cooling Degree Days.** The heating and cooling degree days shall be selected from the Standard RS-1. For locations not listed therein, other sources of heating and cooling degree data may be used provided such sources are approved by the Building Official.

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

Zone 1. Less than 6,000 degree days at 65 degrees F Base.

Zone 2. 6,000 to 8,000 degree days at 65 degrees F Base.

Zone 3. More than 8,000 degree days at 65 degrees F Base.

## SECTION 303

## MECHANICAL VENTILATION CRITERIA

### 303.1 Ventilation

-->

For minimum ventilation requirements see the Uniform Building Code. See also section 502.1.8.

If a mechanical ventilation system is provided in lieu of natural ventilation, the mechanical ventilation system shall be capable of supplying to each zone ventilation air with the minimum outdoor air quantities specified in Table No. 3-1 based upon the greater of the occupant densities in that table or the design occupant density. The outdoor air shall be conveyed by ducts to each zone not provided with minimum openable area for natural ventilation. The maximum outdoor air quantities used as the basis for calculating the heating and cooling design loads shall not exceed three times the quantities specified in Table No. 3-1. See the Uniform Mechanical Code for other requirements.

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

2. Except as limited in this Section, recirculated air may be used to meet part of the outdoor air requirements provided that an air cleaning system is installed which is designed to remove particulate and gaseous contaminants and which otherwise complies with Section 6.1.4 of Standard RS-3. A minimum of 5 cfm of outdoor air per person shall be provided.

TABLE NO. 3-1
OUTDOOR AIR REQUIREMENTS FOR VENTILATION[1]

| | Estimated Occupancy[2] persons per 1000 sq ft[2] | Outdoor Air Requirements cfm/person (except as noted) |
|---|---|---|
| Dry Cleaners and Laundries | | |
| Commercial | 10 | 15 |
| Storage/pick-up areas | 30 | 35 |
| Coin-operated laundries[3] | 20 | 35 |
| Coin-operated dry cleaning | 20 | 15 |
| Food & Beverage Services | | |
| Dining rooms | 70 | 35 |
| Kitchens | 20 | 10 |
| Cafeterias, fast food facilities | 100 | 35 |
| Bars and cocktail lounges | 100 | 50 |
| Garages, Auto Repair Shops, Service Stations | | |
| Parking garages (enclosed)[4] | (cfm/sq ft) | 1.5 |
| Auto Repair workrooms (general)[4] | " | 1.5 |
| Hotels, Motels, Resorts, Dormitories & Correctional Facilities[5] | | |
| Bedrooms (single, double)[6] | (cfm/room) | 30 |
| Living rooms (suites)[6] | " | 50 |
| Baths, toilets (attached to bedrooms)[7] | " | 50 |
| Lobbies | 30 | 15 |
| Conference rooms (small) | 50 | 35 |
| Assembly rooms (large) | 120 | 35 |
| Gambling casinos | 120 | 35 |

TABLE NO. 3-1 (continued)
OUTDOOR AIR REQUIREMENTS FOR VENTILATION

| | Estimated Occupancy persons per 1000 sq ft | Outdoor Air Requirements cfm/person (except as noted) |
|---|---|---|
| Offices | | |
| Office space | 7 | 20 |
| Meeting and waiting spaces | 60 | 35 |
| Public Spaces | | |
| Corridors and utility rooms | (cfm/sq ft) | .02 |
| Public restrooms | (cfm/stall/urinal) | 75 |
| Locker & dressing rooms | (cfm/locker) | 35 |
| Retail Stores | | |
| Sales floors & showrooms | | |
| Basement & street floors | 30 | 25 |
| Upper floors | 20 | 25 |
| Storage areas (serving sales and storerooms) | 15 | 25 |
| Dressing rooms | -- | 25 |
| Malls and arcades | 20 | 10 |
| Shipping & receiving areas | 10 | 10 |
| Warehouses | 5 | 10 |
| Elevators | -- | 15 |
| Smoking rooms | 70 | 50 |
| Specialty Shops | | |
| Barber & beauty shops | 25 | 35 |
| Reducing salons, health spas (exercise rooms) | 20 | |
| Florists[a] | 10 | 25 |
| Greenhouses | 1 | |
| Show repair shops (combined workrooms/trade areas) | 10 | 15 |
| Pet shops | | 1 |

TABLE NO. 3-1 (continued)
OUTDOOR AIR REQUIREMENTS FOR VENTILATION

| | Estimated Occupancy persons per 1000 sq ft | Outdoor Air Requirements cfm/person (except as noted) |
|---|---|---|
| Sports and Amusement Facilities | | |
| Ballrooms and discos | 100 | 35 |
| Bowling alleys (seating area) | 70 | 35 |
| Playing floors (e.g. gymnasiums, ice arenas)[9] | 30 | 20 |
| Spectator areas | 150 | 35 |
| Game rooms (e.g. cards & billiards rooms) | 70 | 35 |
| Swimming pools | | |
| Pool and deck areas[10] | (cfm/sq ft) | .5 |
| Spectators' area | 70 | 35 |
| Theatres | | |
| Ticket booths | | 20 |
| Lobbies, foyers, lounges & auditoriums in motion picture theatres, lecture, concert & opera halls | 150 | 35 |
| Stages, TV and movies studios[11] | 70 | 10 |
| Transportation | | |
| Waiting rooms, ticket & baggage areas, corridors & gate areas, platforms, concourses[12] | 150 | 35 |
| Workrooms | | |
| Meat processing rooms[13] | 10 | 5 |
| Pharmacists' workroom | 20 | 7 |
| Bank vaults | 10 | 5 |
| Photo studios | | |
| Camera room, stages | 10 | 5 |
| Darkrooms | 10 | 20 |
| Duplicating & printing rooms[14] | (cfm/sq ft) | 0.5 |

TABLE NO. 3-1 (continued)
OUTDOOR AIR REQUIREMENTS FOR VENTILATION

| | Estimated Occupancy persons per 1000 sq ft | Outdoor Air Requirements cfm/person (except as noted) |
|---|---|---|
| Educational Facilities | | |
| Classrooms | 50 | 25 |
| Laboratories[15] | 30 | 10 |
| Training shops | 30 | 35 |
| Music rooms | 50 | 35 |
| Libraries | 20 | 5 |
| Hospital, Nursing & Convalescent Homes[16] | | |
| Patient rooms | (cfm/bed) | 35 |
| Medical procedure areas[17] | 10 | 35 |
| Operating rooms, delivery rooms | 20 | 40 |
| Recovery & intensive care rooms | 20 | 15 |
| Autopsy rooms[18] | 20 | 100 |
| Physical therapy areas | 20 | 15 |
| Residential[19] | | |

## Footnotes to Table 3-1

1. Derived from Standard RS-3.

2. Use only when design occupancy is not known.

3. Dry cleaning processes may require more air.

4. Distribution must consider worker location and concentration of running engines, stands where engines are run must incorporate systems for positive engine exhaust withdrawal.

5. See also food and beverage services, merchandising, barber and beauty shops, and garages.

6. Independent of room size.

7. Independent of room size, installed capacity for intermittent use.

8. Ventilation to optimize plant growth may dictate requirements.

9. When internal combustion engines are operated for maintenance of playing surfaces, increased ventilation rates will be required.

10. Higher values may be required for humidity control.

11. Special ventilation will be needed to eliminate special stage effects (e.g., dry ice vapors, mists, etc.)

12. Ventilation within vehicles will require special consideration.

13. Spaces maintained at low temperatures (-10°F to +50°F) are not covered by these requirements unless the vacancy is continuous. Ventilation from adjoining space is permissible. When the occupancy is intermittent, infiltration will normally exceed the ventilation requirement.

14. Installed equipment must incorporate positive exhaust and control (as required) of undesirable contaminants (toxic or otherwise).

15. Special contaminant control systems may be required for processes or functions including laboratory animal occupancy.

Footnotes Continued

16. Special requirements or codes and pressure relationships may determine minimum ventilation rates and filter efficiency.

17. Procedures generating contaminants may require higher rates.

18. Air shall not be recirculated into other spaces.

19. See section 502.1.8.

# CHAPTER 4

## BUILDING DESIGN BY SYSTEMS ANALYSIS ~~AND DESIGN OF BUILDINGS UTILIZING NONDEPLETABLE ENERGY SOURCES~~

## SECTION 401

## SCOPE

### 401.1 General

This chapter establishes design criteria in terms of total energy use by a building, including all of its systems. Analysis of design for low rise R-1 and R-3 occupancies and other buildings less than 5000 sq ft shall comply with Section 402.6. Analysis of design for other buildings shall comply with Sections 402.1 to 402.5.

## SECTION 402

## SYSTEMS ANALYSIS

### 402.1 Energy Analysis For All Buildings Except Lowrise R-1 and R-3 occupancies and other buildings less than 5000 sq ft.

Compliance with this chapter will require an analysis of the annual electric energy usage, hereinafter called an annual energy analysis.

> **EXCEPTION:** Chapters 5, 6 and 7 of this code establish criteria for different energy-consuming and enclosure elements of the building which, ~~if followed~~, will eliminate the requirement for an annual energy analysis while meeting the intent of this code.

A building designed in accordance with this chapter will be deemed as complying with this code if the calculated annual energy consumption is not greater than a similar building (defined as a "standard design") whose enclosure elements and energy-consuming systems are designed in accordance with Chapter 5.

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

### 402.2 Design

The standard design, conforming to the criteria of Chapter 5 ~~or--Chapter--6~~ and the proposed alternative design shall be designed on a common basis as specified herein:

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

### 402.3 Analysis Procedure

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

a. The building heating/cooling load calculation procedure used for annual energy consumption analysis shall be detailed to permit the evaluation of effect of factors specified in Section 402.4.

b. The calculation procedure used to simulate the operation of the building and its service systems through a full-year operating period shall be detailed to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer s data or comparable field test data shall be used when available in the simulation of systems and equipment. The calculation procedure shall be based upon 8760 hours of operation of the building and its service systems and shall utilize the design methods specified in Standards RS-1, -11, -12 and -13.

### 402.4 Calculation Procedure

The calculation procedure shall cover the following items:

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

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

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

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

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

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

### 402.5 Documentation

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

-->

### 402.6 Energy Analysis for Lowrise R-1 and R-3 Occupancies and other buildings less than 5000 sq.ft.

**402.6.1 Energy Budgets.** Proposed buildings designed in accordance with this section shall be designed to use no more kilowatt hours (kWh) of electric energy from depletable sources for space heating than a similar building whose enclosure elements and energy consuming systems are designed in accordance with Section 502.2 of this Code for the appropriate climate zone and building type. New buildings shall also meet the applicable requirements of Sections 502.4, 503.8 and 504.

**402.6.2 Calculation of Energy Consumption.** The application for a building permit shall include documentation which demonstrates, using an approved calculation procedure, that the proposed building's space heating energy use does not exceed the space heating energy use of a similar building conforming to Chapter 5 of this Code for the appropriate climate zone. The total calculated annual electricity consumption shall be shown in units of kWh/sq ft or Btu/sq ft of conditioned area.

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

| Parameter | Value |
|---|---|
| Thermostat set point,heating | 65 degrees F |
| Thermostat set point,cooling | 78 degrees F |
| Thermostat night set back | 0 degrees F |
| Thermostat night set back period | 0 hours |
| Internal gain from lights, appliances and occupants | 3000 Btu/hr (for R-3 occupancies)<br>1500 Btu/hr (R-1 occupancies) |

| | |
|---|---|
| Minimum heat storage | Calculated using standard engineering practice for the actual building or as approved. |
| Site weather data | Typical meteorological year (TMY) or ersatz TMY data for the closest appropriate TMY site or other sites as approved. |
| Heating system efficiency | Systems providing electric resistance heat other than heat pumps are assumed to have an efficiency of 1.00. |

Parameter values that may be varied by the building designer to model energy saving options include, but are not limited to, the following:

1. Overall thermal transmittance, $U_o$, of building envelope or individual building components.
2. Heat storage capacity of building;
3. Glazing orientation and area; and,
4. Heating system efficiency.

**402.6.4 Solar Shading and Access.** Building designs using passive solar features with 8 percent or more south facing equivalent glass to qualify shall provide to the Building Official a sun chart or other approved documentation depicting actual site shading for use in calculating compliance under this section. Building designs shall also document future solar access by indicating on the site plan that the solar aperture will not be shaded by a hypothetical six foot fence built on adjacent lot lines or by a hypothetical "pole" located at the center of the buildable area of adjacent lots that represents the average height of similar structures in the area.

**402.6.5 Infiltration.** Infiltration levels used shall be consistent with the air leakage control package selected from Section 502.4 or the designer shall provide documentation for alternative assumptions.

**402.6.6 Heat Pumps.** The heating season performance factor (HSPF) for heat pumps shall be calculated using procedures consistent with Section 5.2 of the U.S. Department of Energy Test Procedure for Central Air Conditioners, including heat pumps published in the December 27, 1979 Federal Register Vol. 44, No. 24.10 CFR 430. Climate data as specified above, the proposed buildings overall thermal performance value (Btu/degrees F) and

| the standardized input assumptions specified above shall be used
| to model the heat pumps HSPF.

-->

# CHAPTER 5

# BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH

## SECTION 501

## SCOPE

**(Tables are found at the end of Chapter 5)**

### 501.1 General

The criteria of this chapter establishes the minimum requirements for the thermal design of the exterior envelope of buildings which use electrical energy as the primary form of space conditioning, and for other electric energy using components associated with the building operation.

## SECTION 502

## BUILDING ENVELOPE REQUIREMENTS

### 502.1 General

**502.1.1** The stated Uo value of any assembly such as roof/ceiling, wall or floor may be increased and the Uo value for other components decreased, provided that the total heat gain or loss for the entire building envelope does not exceed the total resulting from conformance to the Uo values specified in this section. Component heat loss or cooling coefficients shall be computed in accordance with the provisions of Chapter 23 and 25 of RS-1 and the requirements of this section.

**502.1.2** In addition to the criteria set forth in this section, the proposed design may take into consideration the thermal mass of building components in considering energy conservation when approved by the building official.

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

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

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

-->

502.1.4 Insulation:

**502.1.4.1. General.** All insulating materials shall comply with sections 1712 and/or 1713 of the Uniform Building Code. All insulation materials shall be placed in the building envelope in such a manner as to provide for uniform R-Value.

**502.1.4.2 Clearances.** Where required, insulation shall be installed with clearances maintained through installation of a permanent retainer.

**502.1.4.3 Access Hatches and Doors.** Access doors from conditioned spaces to unconditioned spaces (e.g., attics and crawl spaces) shall be weatherstripped and insulated to a level equivalent to the insulation on the surrounding surfaces. Access shall be provided to all equipment which prevents damaging or compressing the insulation.

**502.1.4.4 Roof/Ceiling.** Blown or poured loose-fill insulation may be used in attic spaces where the slope of the roof is not less than 2-1/2 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 joists 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 prior to the framing inspection. Baffles shall be of weather-resistant, rigid material.

**502.1.4.5 Wall Insulation.** Insulation installed in exterior walls shall comply with the provisions of this section. All wall insulation batts shall fill the entire cavity and shall not be compressed. Exterior wall cavities isolated during framing shall be fully insulated to the levels of the surrounding walls.

**502.1.4.6 Slab-On-Grade.** Slab-on-grade 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 distance of 24 inches. Insulation installed outside the foundation shall extend downward to a maximum of 24 inches or to the frostline. Above grade insulation shall be protected.

> **EXCEPTION:** For monolithic slabs, the insulation shall extend downward from the top of the slab to the bottom of the footing.

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

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

**502.1.5 Glazing: For low-rise R-1 and R-3 occupancies and other buildings less than 5000 sq ft.** Compliance with the U-Values for glazing shall be certified using thermal transmittance due to conduction test results from either RS-2B or RS-2C test procedures. Testing shall be conducted by a certified laboratory at a wind speed of 15 mph and using the residential sample size specified in RS-2B. For the purpose of calculations the tested U-value may be adjusted to reflect a seasonal average condition of 7.5 mph using the procedure specified in Chapter 27 of RS-1.

**EXCEPTION:** U-Values for site- built fixed lites shall use window thermal test results when available.

**502.1.6 Moisture control.**

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

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

**502.1.6.2 Walls, Ceilings, and Floors.** Walls, ceilings, and floors separating conditioned space from unconditioned space shall have a vapor retarder installed. The vapor retarder shall have a one perm dry cup rating or less.

**502.1.6.3 Slab-On-Grade.** Slab-on-grade floors shall have a ground cover with a one-perm dry cup rating and approved for under slab use installed beneath the entire slab.

**EXCEPTION:** Slabs installed on a 2" minimum gravel base.

**502.1.6.4 Ground Cover.** A black ground cover of 6 mil (0.006 inch thick) polyethylene or approved equal shall be laid over the ground within crawl spaces. The ground cover shall be overlapped 12 inches minimum at joints and shall extend to the foundation wall.

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

**502.1.7 Indoor Air Quality for Lowrise R-1 and R-3 Occupancies**

**502.1.7.1.** All structural panel components within the conditioned space shall comply with RS-24 for formaldehyde emissions of .2 PPM for plywood and .3 PPM for particle board and shall be so labeled.

**EXCEPTION:** Softwood plywood, particle board, wafer board and oriented strand board with phenol based resins and stamped EXPOSURE 1 or EXTERIOR.

**502.1.7.2.** Concrete slabs shall be a minimum 3-1/2" thick and shall be installed over a 4" thick coarse-grade gravel base.

**502.1.7.3.** Combustion appliances located within the conditioned space shall be either direct vent, forced draft or, other venting system taking combustion air directly from the exterior.

**EXCEPTIONS:** 1. Fireplaces and wood stoves shall comply with Section 502.4.3.5.
2. Cooking appliances.

**502.1.8 Mechanical Ventilation for low-rise R-1 and R-3 occupancies.** Not withstanding the requirements of Section 303 and UBC Section 1205(a), a ventilation system complying with NWEC Standard #25 and #26 shall be installed. The ventilation system shall be capable of providing the following ventilation requirements:

1. **Spot Ventilation.** Exhaust ventilation of 50 cfm for each bathroom and 100 cfm for each kitchen capable of intermittent operation.

2. **Whole House Ventilation.** Outdoor air shall be supplied to the conditioned space at the rate of 10 cfm for each bedroom plus an additional 10 cfm for the remaining living area. The ventilation system shall be capable of providing the outdoor air on a continuous basis and shall be provided with an automatic control with a manual override.

**502.2 Criteria For All Lowrise Group R-1 and R-3 Occupancies and For Other Buildings Less Than 5000 sq.ft.**

The building envelope will be deemed as complying with this code if the calculated heat loss of the proposed building is not greater than the heat loss of a reference building complying with the requirements of Table No. 5-1. The building heat loss shall be calculated using Equation 5.1, 5.2, 5.3 and 5.4.

The reference building shall have the same floor areas, gross exterior wall area, gross ceiling area and below grade wall or slab-on grade perimeters as the proposed building. The reference building shall use an air exchange rate of .35 ACH.

Component heat loss coefficients shall be calculated using the procedures in Chapters 23 and 25 of RS-1. The effects of all heat flow paths, including framing members and tapering or compression of the insulation shall be included. The buffering effects of adjacent unheated spaces may be considered. The seasonal average outdoor conditions may be used for determination of the outdoor air films.

$$U = \frac{1}{\frac{1}{f_o} + R_1 + R_2 + \ldots R_n + \frac{1}{f_i}} \quad \text{...(Equation 5.1)}$$

**WHERE:** $U$ = the thermal transmittance of the assembly. (Btu/hr·sq.ft.·°F)

$f_o$ = outside air film conductance

$f_i$ = inside air film conductance

$R = \frac{1}{C}$ = measure of the resistance to the passage of heat for each element. (°F/Btu·sq.ft.·hr)

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

General Equation for heat loss:

$$UA = U_i A_i \quad \text{or} \quad F_i P_i \text{.........(Equation 5.2)}$$

**WHERE:**

$UA$ = component heat loss

$U_i$ = component U-Value

$A_i$ = component area (sq ft)

*$F_i$ = component F-factor

*$P_i$ = component perimeter (ft)

*(for slabs and below grade walls)

Effective Air Leakage Heat Loss Rate:

$UA_i$ = ACH x V x $C_p$ x D..(Equation 5.3)

**WHERE:**

$UA_i$= heat loss from infiltration
*ACH= effective air exchange rate
V = Volume of conditioned space
$C_p$ = specific heat capacity of air
D = density of air at building location

* use .35 ACH for the Standard air leakage controls
.20 ACH for the Advanced air leakage controls

Building Total Heat Loss Rate:

$UA_o$ = $FP_b$ + $FP_s$ + $UA_f$ + $UA_w$ + $UA_g$ + $UA_d$ + $UA_c$ + $UA_i$.....(Eq 5.4)

**WHERE:**

$FP_b$ = UA for below grade walls
$FP_s$ = UA for slab on grade floors
$A_f$ = UA for floors over unconditioned spaces
$UA_w$ = UA for walls above grade
$UA_g$ = UA for glazing
$UA_d$ = UA for doors
$UA_c$ = UA for ceilings
$UA_i$ = UA for air infiltration

All units in Btu/hr/degrees F

* - See Section 201 for definition of glazing.

-->

## 502.3 Criteria for All Other Buildings

### 502.3.1 Heating Criteria.

**502.3.1.1 Walls.** The gross exterior wall shall have a combined thermal transmittance value ($U_o$) not exceeding the values given in Table No. 5-2. Equations 5.1 and 5.5 shall be used to determine acceptable combinations to meet this requirement. For below-grade-walls , the thermal resistance of the insulation shall not be less than the value given in Table No. 5-2.

-->

General equation for gross wall area:

$$U_o = [U_w \times A_w + U_g \times A_g + U_d \times A_d]/A_o \ldots \text{(Equation 5.5)}$$

**WHERE:**
Uw = average thermal transmittance of opaque wall.
Aw = opaque area of exterior walls above grade.
Ug = the thermal transmittance of the glazing.
Ag = the glazing area, including sash.
Ud = the thermal transmittance of the door.
Ad = the door area.
Uo = the average thermal transmittance of the gross wall area
Ao = the gross wall area

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

(Uw1 x Aw1) + (Uw2 x Aw2), + ... etc.

Calculations shall include the effects of all heat flow paths, including framing members.

**502.3.1.2 Roof/Ceiling.** The gross roof/ceiling ~~building that-is-heated-and/or-mechanically-cooled~~ shall have a combined thermal transmittance value (Uo) ~~for-the-gross-area-of-the-roof assembly~~ not exceeding the value given in Table No. 5-2. Equations 5.1 and 5.6 shall be used to determine acceptable combinations to meet this requirement.

General equation for gross roof/ceiling area:

$$U_o = [U_r \times A_r + U_s \times A_s]/A_o \ldots\ldots\ldots\ldots \text{(Equation 5.6)}$$

**WHERE:**
Ur = the thermal transmittance of opaque roof/ceiling.
Ar = opaque roof/ceiling area.
Us = the thermal transmittance of skylight.
As = skylight area (including frame).
Uo = the average thermal transmittance of the gross roof/ceiling
Ao = the gross roof/ceiling area

Note: Where more than one type of roof/ceiling and/or skylight is used, the U x A term for that exposure shall be expanded into its sub-elements, as:

(Ur1 x Ar1) + (Ur2 x Ar2), + ... etc.

Calculations shall include the effects of all heat flow paths, including framing members.

**502.3.1.3 Floors over unheated spaces.** For floors of heated spaces over unheated spaces, the Uo value shall not exceed the value given in Table No. 5-2. ~~For floors over outdoor air, exposed to exterior ambient conditions (i.e., overhangs), Uo values for heating shall meet the same requirements as shown for the gross roof/ceiling in Table No. 5-2.~~

**502.3.1.4 Slab-on-grade floors.** For heated and unheated slab-on-grade floors, the thermal resistance of the insulation around the perimeter of the floor shall be not less than the value given in Table No. 5-2. ~~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 and shall be of an approved type.~~

**502.4 Air Leakage for All Buildings**

**502.4.1 General.** The requirements of this section shall apply to all buildings and structures, or portions thereof, and apply to those locations separating exterior ambient conditions from interior spaces that are heated and/or mechanically cooled and are not applicable to the separation of interior conditioned spaces from each other.

**502.4.2** Exterior doors and windows shall be designed to limit air leakage into or from the building envelope. Manufactured doors and windows shall have air infiltration rates not exceeding those shown in Table No. 5-3. Site-constructed doors and windows shall be sealed in accordance with 502.4.3.

**502.4.3 Standard Air Leakage Control:**

**502.4.3.1** These requirements shall apply to all buildings.

**502.4.3.2 Penetrations.** The following openings in the building envelope shall be caulked or otherwise sealed to limit infiltration: a. Around glazing and door frames, between the unit and the interior sheet rock or the rough framing;

b. Between all exterior wall sole plates and the structural floor, using two rows of caulking or an alternate approved procedure;

c. Over all framing joints where floors over conditioned spaces intersect exterior walls (e.g., at rim and band joists), using a high permeance infiltration barrier or alternate approved technique;

d. Around penetrations in the building envelope for ducts, plumbing, electrical and utilities in walls, ceilings and floors;

e. At all openings or joints in the ceiling membrane;

f. At the top and bottom of the mudsill (basements only and

underfloor plenums);
g. At all other penetrations in the building envelope.

**502.4.3.3 Electric Outlets.** Electric outlet plate gaskets shall be installed or the boxes sealed on all electrical outlets in the exterior walls, ceiling or floor.

**502.4.3.4 Ducts.** HVAC ducts shall be sealed at all joints and corners , at junctions between outlet registers and interior surfaces.

**502.4.3.5 Wood stoves and Fireplaces.** Masonry and factory-built fireplaces and wood stoves shall be installed with the following: a. Tight-fitting, closeable metal or glass doors covering the entire opening of the firebox.

b. A combustion air intake from outside of the conditioned space directly into the firebox, at least 6 square inches in area, and equipped with a readily accessible, operable, and tight-fitting damper.

c. For masonry fireplaces only, a tight-fitting flue damper with a readily accessible manual control.

**502.4.3.6 Exhaust Systems:** Fans or other systems exhausting air from the building to the outside shall be provided with backdraft or automatic dampers to limit air leakage.

> **EXCEPTION:** Lowrise R-1 and R-3 occupancies and other buildings less than 5000 sq ft shall be exempt from all of the requirements of Section 502.4.2 and 502.4.3 if: a. The air exchange rate for the building is 7.0 air changes per hour or less when tested in accordance with RS-22 when depressurized to 50 pascals, or
>
> b. The average air exchange rate for the building is .35 ACH or less as measured over a two week period of the heating season when tested in accordance with RS-23.

**502.4.4 Advanced Air Leakage Control.** These requirements may only be used for low rise R-1 and R-3 occupancies or other occupancies less than 5000 sq. ft. In addition to the requirements of Section 502.4.3, the following shall be provided: a. An air-to-air heat exchanger or exhaust air heat pump complying with the requirements of NWEC Standard #25 and #26.

b. Continuous Air Barrier: A continuous air barrier installed over all exterior ceilings, exterior floors, and exterior walls and sealed at all intersections of these components to create a continuous air barrier over the entire envelope of the building. Joints shall be structurally supported and sealed. Flexible sheet air infiltration barriers shall be lapped at least 6 inches at a framing member, and permanently fixed to prevent separation. All openings in the air barrier including rips and tears shall be sealed. Ceilings with plank and beam construction exposed to the conditioned space shall have the air barrier placed on top of the planking and sealed directly to the wall air barrier with compression gaskets, caulking or sealant as approved. Post and beam floors with decking shall have the air barrier placed on top of the decking and sealed directly to the wall air barrier with compression gaskets, caulking or sealant as approved.

**EXCEPTION:** Buildings shall be exempt from all requirements of Section 502.4.2, 502.4.3 and 502.4.4.b. provided: a. The air exchange rate for the building is 1.8 air changes per hour or less when tested in accordance with RS-22 when depressurized to 50 pascals; or

b. The average air exchange rate for the building is .1 ACH or less seasonal average without the heat recovery ventilation in operation or .35 ACH seasonal average with heat recovery ventilation system in operation as measured over a two week period of the heating season when tested in accordance with RS-23.

-->

## SECTION 503

## BUILDING MECHANICAL SYSTEMS

### 503.1 General

This section covers the determination of heating and cooling loads, design requirements, system and component performance, control requirements, insulating systems and duct construction.

**EXCEPTION:** Special applications for process loads ~~including, but not limited to, hospitals, laboratories, thermally sensitive equipment rooms, computer rooms, and facilities with open refrigerated display cases~~ may be exempted from the requirements of Section 503 when approved by the building official.

### 503.2 Calculations of Heating and Cooling Loads and System Sizing Limits

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

**503.2.1 Calculation Procedures.** Heating and cooling design loads for the purpose of sizing systems shall be determined in accordance with one of the procedures described in Chapters 25 and 26 of Standard RS-1 or an equivalent computation procedure.

**503.2.2 Infiltration.** Infiltration for heating and cooling design loads shall be calculated for all buildings ~~except one and two family dwellings may use~~ using the methods identified above or other accepted engineering practice by the procedures in Chapter 22 of Standard RS-1. ~~Calculations for one and two family dwellings may use the methods identified above or other accepted engineering practice.~~

**503.2.3 Space Heating and Cooling System Sizing Limits for Low-Rise R-1 and R-3 Occupancies and other buildings less than 5000 sq.ft.** Building mechanical systems which provide space heating and/or space cooling shall be sized no greater than 150 percent of the design load as calculated above.

> **EXCEPTION:** For heat pumps, compliance need only be demonstrated for either the space heating or space cooling system size. Where compliance is demonstrated for the space cooling system size, the supplementary heat element either shall be the smallest element available for that heat pump or the sum of the heat pump element plus the supplementary heat element shall not exceed 150 percent of the design heating load.

**503.3 Simultaneous Heating and Cooling**
-->
Each temperature control zone shall include thermostatic controls installed and operated to sequence the use of heating and cooling energy to satisfy the thermal and/or humidity requirement of the zone. Controls shall prevent reheating (heating air that is cooler than system mixed air), recooling (cooling air that is warmer than the system mixed air), mixing or simultaneous supply of warm air (warmer than system return air mixed air) and cold air (cooler than system mixed air), or other simultaneous operation of heating and cooling systems to one zone. For the purposes of this section, system mixed air is defined as system return air mixed with the minimum ventilation air requirement by Section 303.1.

> **EXCEPTIONS:** 1. Variable air volume systems designed to reduce the air supply to each zone during periods of occupancy to the larger of the following:
> a. 30% or less of the peak supply volume.
> b. The minimum allowed to meet ventilation requirements of Section 303.1.
> c. 0.5 cfm/ft.$^2$ of zone conditioned area before reheating, recooling or mixing takes place. Consideration shall be given to supply air temperature reset control.

2. The energy for reheating, or providing warm air in mixing systems, is provided entirely from recovered energy that would otherwise be wasted, or from nondepletable energy sources. In addition, the system shall comply with Section 503.7 without exception.

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

4. Where special pressurization relationships or cross-contamination requirements are such that variable air volume systems are impractical, supply air temperatures shall be reset by representative building load or outside air temperature.

**503.4 HVAC Equipment Performance Requirements**

**503.4.1 Equipment Components.**

**503.4.1.1** The requirements of this section apply to equipment and mechanical component performance for heating, ventilating and air-conditioning systems. Equipment efficiency levels are specified. Data furnished by the equipment supplier or certified under a nationally recognized certification program or rating procedure shall be used to satisfy these requirements. Equipment efficiencies shall be based on the standard rating conditions in Table No. 5-7, 5-8 or 5-9 as appropriate.

**503.4.1.2** Where components from more than one manufacturer are assembled into systems regulated under this section, compliance shall be as specified in paragraphs 503.4.2 through 503.4.6

**503.4.2 HVAC System Heating Equipment Heat Pump-heating Mode.** Heat pumps whose energy input is entirely electric shall have a coefficient of performance (COP) heating, not less than the values in Table No. 5-4.

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

**503.4.2.2 Coefficient of performance (COP) heating.** The ratio of the rate of net heat out to the rate of total on-site energy input to the heat pump, 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 and heat from boilers).

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

**503.4.2.3 Supplementary Heater.** The heat pump shall be installed with a control to prevent supplementary hater operation when the operating 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.

A two-stage thermostat, which controls the supplementary heat on its second stage, 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, including, but not limited to, electric resistance, combustion heating or solar or stored-energy heating.

**503.4.3 (reserved)**

**503.4.4 Mechanical Ventilation.** Each mechanical ventilation system (supply and/or exhaust) shall be equipped with a readily accessible switch or other means for shutoff or volume reduction and shutoff when the ventilation is not required. Automatic or gravity dampers that close when the system is not operating shall be provided for outdoor air intakes and exhausts. There is no standard at this time for damper leakage. Automatic or manual dampers installed for the purpose of shutting off ventilation systems shall be designed with tight shutoff characteristics to minimize air leakage.

> **EXCEPTIONS:** Manual dampers for outdoor air intakes may be used in the following cases: For R1 and R3 buildings; or when the fan system capacity is less than ~~5000~~ 3500 cfm.

**503.4.5 HVAC System Equipment, Electrically Operated, Cooling Mode.** HVAC system equipment as listed below, whose energy input in the cooling mode is entirely electric, shall have an energy efficiency ratio (EER) or a Coefficient of Performance (COP) cooling not less than values in Table No. 5-5.

**503.4.5.1** These requirements apply to, but are not limited to, unitary (central) and packaged terminal heat pumps (air source and water source); packaged terminal air conditioners and room air temperatures.

> **EXCEPTION:** These requirements do not apply to equipment used in areas such as supermarkets having open refrigerated food display cases or computers or other equipment contributing a large amount of heat to the area served.

**503.4.5.2 Coefficient of Performance (COP) Cooling.** The COP is the ration of the rate of net heat removal to the rate of total on-site energy input to the air conditioner expressed in consistent units and under designated rating conditions.

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

Total on-site energy input shall be determined by combining the energy inputs to all elements supplied with the package of the equipment including but not limited to compressor(s), compressor sump heater(s), pumps(s), supply-air fans(s), return-air fan(s), condenser-air fan(s), cooling-tower fan(s) and pump(s) and the HVAC system equipment control circuit.

**503.4.6 Applied HVAC System Components, Electrically Operated, Cooling Mode.** HVAC System components, as listed in Table NO. 5-6, whose energy input is entirely electric, shall have an energy efficiency ratio (EER) or a Coefficient of Performance (COP) cooling not less than the values in Table 5-6.

**503.4.6.1 Coefficient of performance (COP) cooling:** The COP is the ration of the rate of net heat removal to the rate of total on-site energy input, expressed in consistent units and under designated rating conditions.

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

Total (on-site) energy input to the component shall be determined by combining the energy inputs to all elements and accessories as included in the component, including but not limited to, compressor(s), internal circulating pump(s), purge devices, and the HVAC system component control circuit.

**503.5 Transport Energy**

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

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

*Expressed in Btu/h or watts

For purposes of these calculations, Space Sensible Heat Removal is equivalent to the maximum coincident design sensible cooling load of all spaces served for which the system provides cooling. Fan Power Input is the rate of energy delivered to the fan prime mover.

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

**503.6 Balancing**

The HVAC system design shall provide an accessible means for balancing air and water systems. In doing so, the considerations shall include, but not be limited to, dampers, temperature and pressure test connections and balancing valves.

**503.7 Cooling with Outdoor Air (Economizer Cycle)**

Each fan system shall be designed to use up to and including 100 percent of the fan system capacity for cooling with outdoor air automatically whenever its use will result in lower usage of new energy. Activation of economizer cycle shall be controlled by sensing outdoor air enthalpy or outdoor air dry-built temperature alone or alternate means approved by the building official.

> **EXCEPTIONS:** Cooling with outdoor air is not required under any one or more of the following conditions: 1. The fan system capacity is less than ~~5000~~ 3,500 cfm or total cooling capacity is less than ~~134,000~~ 90,000 Btu/h.
> 2. The quality of the outdoor air is so poor as to require extensive treatment of the air and approval by the building official.
> 3. The need for humidification or dehumidification requires the use of more energy than is conserved by the outdoor air cooling on an annual basis.

4. The use of outdoor air cooling may affect the operation of other systems so as to increase the overall energy consumption of the building.
5. When energy recovered from an internal/external zone heat recovery system exceeds the energy conserved by outdoor air cooling on an annual basis.

-->

6. When all space cooling is accomplished by a circulating liquid which transfers space heat directly or indirectly to a heat rejection device such as a cooling tower without use of a refrigeration system.
7. When the use of 100 percent outside air will cause coil frosting, controls may be added to reduce the quantity of outside air. However, the intent of this exception is to use 100 percent air in lieu of mechanical cooling when less energy usage will result and this exception applies only to direct expansion systems when the compressor(s) is running.

-->

8. For dwelling portions of R-1 and R-3 occupancies.

## 503.8 Controls

**503.8.1 Temperature Control.** Each system shall be provided with at least one adjustable thermostat for the regulation of temperature. Each thermostat shall be capable of being set by adjustment or selection of sensors as follows:

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

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

**503.8.1.3** When used to control both heating and cooling, it shall be capable of being set from 55 to 85 degrees F and shall be capable of operating the system heating and cooling in sequence. The thermostat and/or control system shall have an adjustable deadband of ~~up-to~~ not less than 10 degrees F except as allowed by the second subparagraph of 503.3.3.5.

**503.8.2 Humidity Control.** If a system is equipped with a means for adding moisture to maintain specific selected relative humidities in space or zones, a humidistat shall be provided. Humidistats shall be capable of being set to prevent new energy from being used to produce space-relative humidity above 30 percent. When a humidistat is used in a system for controlling moisture removal to maintain specific 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 of less than 60 percent.

**EXCEPTION:** Special occupancies requiring different relative humidities may be permitted.

**503.8.3 Zoning for Temperature Control**

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

**503.8.3.2 Multifamily Dwellings.** For multifamily dwellings, each individual dwelling unit shall have at least one thermostat for regulation of space temperature. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each room. Spaces other than living units shall meet the requirements of 503.8.3.3.

**503.8.3.3 Other types of buildings or occupancies.** At least one thermostat for regulation of space temperature shall be provided for: a. Each separate system.

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

**503.8.3.4 Control setback and shutoff.** a. One- and Two-Family and Multifamily Dwellings: The thermostat required in 503.8.3.1 and 503.8.3.2 or an alternate means, including, but not limited to, a switch or clock, shall provide a readily accessible manual or automatic means for reducing the energy required for heating and cooling during periods of nonuse or reduced need including, 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 system shall be equipped with a readily automatic means of shutting off or reducing the energy used during periods of nonuse or alternate uses of the building spaces or zones served by the system. Acceptable means include, but are not limited to:

Manually adjustable automatic timing devices.
Manual devices for use by operating personnel.
Automatic control systems.

**503.9 Air Handling Duct System Insulation.**

Ducts, plenums and enclosures installed in or on buildings shall be thermally insulated as follows:

**503.9.1.** Duct systems, or portions thereof, shall be insulated to provide a thermal resistance, excluding air films of R-11 when installed outside the conditioned space. A weatherproof barrier shall be provided to protect any exterior insulation. All ducts for mechanical cooling shall provide a vapor retarder with a drycup rating not greater than 0.05 perm.

**EXCEPTIONS:** Duct insulation (except where required to prevent condensation) is not required in any of the following cases:
1. When the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building.
2. Within the HVAC equipment.
3. Exhaust air ducts.

-->

**503.10 Duct Construction**

Duct work shall be constructed and ~~erected~~ installed in accordance with Standards RS-15, RS-16, RS-17, RS-18, RS-19 or RS-20, as applicable, and the Uniform Mechanical Code.

**503.10.1** High-pressure and medium-pressure ducts shall be leak tested in accordance with the applicable standards in Chapter 8 of this code with the rate of air leakage not to exceed the maximum rate specified in that standard.

**503.10.2** When low-pressure supply air ducts are located outside of the conditioned space, all ~~transverse~~ joints shall be sealed. All material used within the air plenum shall comply with the Uniform Mechanical Code.

**503.10.3** Automatic or manual dampers installed for the purpose of shutting off outside air intakes for ventilation air shall be designed with tight shutoff characteristics to minimize air leakage.

**503.11 Piping Insulation.** All piping installed to serve buildings (and within) shall be thermally insulated in accordance with Table No. 5-10. Fo service hot water systems see section 504.7.

**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 and 100 degrees 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.

**503.11.1. Other Insulation Thickness.** Insulation thickness in Table No. 5-10 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 degree F. Minimum insulation thickness shall be increased for materials having "R" values less than 4.0 per inch, or may be reduced for materials having "R" values greater than 4.6 per inch.

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

$$\frac{4.6 \times (\text{Table 5-10 Thickness})}{\text{Actual Resistance}} = \text{New Minimum Thickness}$$

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

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

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

## SECTION 504

## SERVICE WATER HEATING

### 504.1 Scope

The purpose of this section is to provide criteria for design and equipment selection that will produce energy savings when applied to service water heating.

### 504.2 Water Heaters, Storage Tanks and Boilers

**504.2.1 Performance Efficiency.**

Electric storage water heaters shall meet the requirements of ASHRAE Standard 90A-80 and be so labeled.

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

floors insulated to a minimum of R-10 shall be deemed to meet with this requirement.
-->

**504.2.2 Insulation.** Heat loss from unfired hot-water storage tanks shall be limited to a maximum of ~~13.6~~ 9.6 Btu/hr/ft of external tank surface area. The design ambient temperature shall be no higher than 65 degrees F.

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

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

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

determined by the fixture count method where:

pmd = probably maximum demand in gallons/hour as determined in accordance with Chapter 37 of Standard RS-11.
n = fraction of year when outdoor daily mean temperature exceeds 64.9 degrees F.

The standby loss is to be determined for a test period of 24 hour duration while maintaining a boiler water temperature of 90 degrees F above an ambient of 60 degrees F and a 5 foot stack on appliance.

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

**504.3 Automatic Controls**

Service water heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use. Temperature setting range shall be in accordance with Table 2 in Chapter 37 of Standard RS-11.

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

**504.5 Swimming Pools**

**504.5.1** All pool heaters shall be equipped with readily accessible ON/OFF switch ~~mounted for easy access~~ to allow shutting off the operation of the heater without adjusting the thermostat setting ~~and to allow restarting without relighting the~~

~~pilot-light.~~ Controls shall be provided to allow the water temperature to be regulated from the maximum design temperature down to 65 degrees F.

**504.5.2 Pool Covers.** Heated swimming pools shall be equipped with an approved pool cover.

-->

**504.6 Pump Operation**

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

**504.7 Pipe Insulation**

For recirculating systems, piping shall be ~~limited--to-a maximum-of-17.5-Btu/h-per-linear-foot-of-pipe~~ thermally insulated in accordance with Table 5-10 ~~for--low-temperature-applications, which-is--based-on--design-external--temperature-no-lower-than-65 degrees-F.--Other-design-temperatures-must-be-calculated.~~

**504.8 Conservation of Hot Water**

**504.8.1 Showers.** Showers used for other than safety reasons shall be equipped with flow control devices to limit the maximum hot water discharge to 3 2.75 gpm rated at distribution pressures from 20 to 80 psi.

**504.8.2 Lavatories in Rest Rooms of Public Facilities shall:**

**504.8.2.1** Be equipped with outlet devices which limit the flow of hot water to a maximum of 0.5 gpm or be equipped with self-closing valves that limit delivery to a maximum of 0.25 gallons of hot water for recirculating systems and to a maximum of 0.50 gallons for nonrecirculating systems.

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

**504.8.2.2** Be equipped with devices which limit the outlet temperature to a maximum of 110 degrees F.

# SECTION 505
# ELECTRICAL POWER AND LIGHTING

## 505.1 General

Electrical power and lighting systems shall be designed to conserve energy as provided herein.

## 505.2 Electrical Energy Consumption

In multifamily dwellings, provision shall be made to determine the electrical energy consumed by each dwelling unit by separately metering individual dwelling units.

**EXCEPTION:** Motels, hotels, college dormitories and other transient facilities.

## 505.3 Lighting Power Budget

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

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

**EXCEPTION:** R-3 occupancies and the dwelling portions of R-1 are exempt from the requirements of Section 505.3.

### 505.3.1 Budget Development.

**505.3.1.1** The installed lighting wattage for 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 subsection 503.3.2 and the exterior budget calculated in accordance with subsection 503.3.4. Lighting wattage includes lamp and ballast wattage.

**EXCEPTION:** The interior lighting budget for office and sales (retail and wholesale) occupancies, when approved by the Building Official, may be calculated using the procedures in Chapter 10.

**505.3.1.2** When insufficient information is known about the specific use of the building space, the budget shall be based on the apparent intended use of the building space.

**505.3.2 Building Interiors.** The interior lighting budget shall be calculated by multiplying the gross floor area, in square feet, by the appropriate unit power budget, in watts per square foot, specified in Table No. 5-11.

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

> **EXCEPTION:** Where the following automatic lighting controls are installed for calculation purposes, the installed lighting wattage may be reduced by the following percentages:a. For occupant-sensing devices, energy savings of 30 percent shall be allowed for any single space up to 250 square feet and enclosed by ceiling height partitions; classrooms, conference rooms, computer rooms, storage areas, corridors, or waiting rooms.
> b. For daylighting controls, energy savings of 30 percent for continuous dimming and 20 percent for stepped controls shall be allowed for spaces which have transparent glazing.
> c. For lumen maintenance controls, energy savings of 10 percent shall be allowed for any space.
> d. For daylighting controls with occupant-sensing devices, energy savings of 44 percent shall be allowed for any single space up to 250 square feet within spaces with transparent glazing & enclosed by ceiling height partitions.
> e. For occupant-sensing devices with lumen maintenance controls, energy savings of 37 percent shall be allowed for any single space up to 250 square feet and enclosed by ceiling height partitions.

-->

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

a. Stage lighting, lighting for art objects, entertainment, or audiovisual presentations where the lighting is an essential technical element for the function performed.
b. Lighting for medical and dental tasks.

c. Lighting in areas specifically designed for visually handicapped people.
d. For restaurant occupancies, lighting for kitchens and food preparation areas.
e. Power required for trickle-charging for battery powered emergency lighting.

-->

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

-->

**505.4 Lighting Switching.**

-->

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

**505.4.1 Switching requirements.**

**505.4.1.1** All lighting controls, except automatic controls or those for special purpose applications which require trained operators or those which would pose a safety problem or a security hazard, shall be installed so as to be readily accessible to personnel occupying or using the lighting space.

**505.4.1.2** The maximum lighting power that may be controlled from a single switch or automatic control shall not exceed that provided by a 20 ampere circuit loaded to no more than 80 percent. A master control may be installed provided the individual switches retain their capability to function independently.

**505.4.1.3** All lighted spaces enclosed by walls or ceiling height partitions and with floor area less than 250 square feet shall be provided an individual, local lighting control or an occupant-sensing automatic control.

**505.4.1.4** All lighted spaces with floor area greater than 250 square feet shall be provided with local controls to permit reducing the lighting by no more than one-half or occupant sensing automatic controls.

**505.4.1.5** All building areas greater than 250 square feet where natural lighting is available shall be provided with individual local controls or daylight- or occupant-sensing automatic controls which permit control of lights independent of general area lighting. Either individual controls shall be provided for each row of luminaries parallel to a window wall or controls shall be provided for each row of luminaries parallel to a window wall or controls shall be provided to reduce the lighting in at least two steps to not more than one-half and to completely off in the natural lighting area. For office and school occupancies, at a minimum, lighting serving a zone within 12 feet of a window wall or the zone between an interior wall and the window wall of less than 12 feet shall comply with this provision. For retail occupancies, at least the row of luminaries nearest the window shall comply with this provision.

**505.4.1.6** All display, exhibition or specialty lighting shall be controlled independently of general area lighting.

**505.4.1.7** All exterior building lighting including facade lighting, parking lots, driveways, walkways, shall be furnished with automatic controls to reduce or turn off all lights during periods of non-use or daylight hours, except those required for safety and security. Sign lights shall be exempt from this provision.

TABLE NO. 5-1
COMPONENT U-VALUE REQUIREMENTS FOR
LOW RISE R1 AND R3 OCCUPANCIES AND
AND OTHER BUILDINGS LESS THAN 5000 SQ FT

| | Climate Zone | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Opaque ceiling | .032 | .032 | .021 |
| Opaque wall | .057 | .043 | .040 |
| Floor | .029 | .029 | .029 |
| Slab on grade[1] | .455 | .455 | .455 |
| Below grade wall[1] | .750 | .750 | .750 |
| Doors | .190 | .190 | .190 |
| Glazing[2] | .390 | .390 | .390 |

Reference glazing area = .15 x Conditioned Floor Area
Air leakage control - Standard (ACH = .35)

1. F-Values- See Chapter 2 for definition
2. Glazing at 7.5 mph seasonal conditions

TABLE NO. 5-2

COMPONENT REQUIREMENTS FOR ALL BUILDINGS
OTHER THAN LOW RISE R-1 AND R-3 OCCUPANCIES AND
OTHER BUILDINGS LESS THAN 5000 SQ FT

| Component | Requirement |
|---|---|
| Space Conditioning System Type | Any |
| Nominal $U_o$ Value-Envelope | |
| Gross roof/ceiling | $U_o$ = .08 |
| Exterior walls in buildings with three stories or less | $U_o$ = .25 |
| More than three stories | $U_o$ = .30 |
| Floors over unconditioned space | $U_o$ = .05 |
| Below grade walls and heated slab on grade floors | R-10 |
| Unheated slab on grade floors | R-8 |
| AIR LEAKAGE CONTROL PACKAGE | STANDARD |

## TABLE NO. 5-3

### ALLOWABLE AIR LEAKAGE RATES[1]

| | WINDOWS | RESIDENTIAL DOORS[2] | | NONRESIDENTIAL DOORS |
|---|---|---|---|---|
| AIR LEAKAGE CONTROL PACKAGE | (cfm per lineal ft of operable sash crack) | SWINGING (cfm per lin ft of operable sash crack) | SLIDING (cfm per sq ft of door) | SWINGING, SLIDING, REVOLVING (cfm per lin ft of crack) |
| Standard | 0.3 | 0.2 | 0.25 | 11.0 |
| Advanced | 0.2 | 0.2 | 0.10 | 11.0 |

1- When tested at a pressure differential of 1.567 lb/ft², which is equivalent to the impact pressure of a 25 mph wind.

2- Compliance with the criteria for air leakage shall be determined by Standard RS-2

## TABLE NO. 5-4

### MINIMUM COP AND HPSF FOR HEAT PUMPS, HEATING MODE[1]

| SOURCE AND OUTDOOR TEMPERATURE (F) | MINIMUM COP LOW RISE R1 & R3 | OTHER OCC | MIN HSPF |
|---|---|---|---|
| Air Source-47DB/43WB | 2.7 | 2.7 | |
| Air Source-17DB/15WB | 2.0 | 1.8 | |
| Air Source | --- | --- | 6.8 |
| Water Source-60 entering | 3.0 | 3.0 | |

1- When tested at the standard rating specified in Table 5-7.

TABLE NO. 5-5

MINIMUM EER AND COP FOR ELECTRICALLY DRIVEN HVAC SYSTEM EQUIPMENT COOLING[1,2]

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

1- When tested at the standard rating conditions specified in Table No. 5-8.

2- The Department of Energy has established required test procedures for single-phase air-cooled residential central air conditioners under 19 KW (65,000 Btu/hr) in capacity, which have been incorporated into ARI Standard 210-79.

## TABLE NO. 5-6

## MINIMUM EER AND COP FOR ELECTRICALLY DRIVEN HVAC SYSTEM COMPONENTS[1,2]

### WATER CHILLING PACKAGES

| | | CONDENSING MEANS | | | | | |
|---|---|---|---|---|---|---|---|
| | | AIR | | WATER | | EVAPORATIVE | |
| TYPE OF COMPONENT | COMPRESSOR TYPE | EER | COP | EER | COP | EER | COP |
| Condenser Included | Centrifugal or rotary | 8.00 | 2.34 | 13.80 | 4.04 | -- | -- |
| | Reciprocating | 8.40 | 2.36 | 12.00 | 3.51 | -- | -- |
| Condenserless water chillers | Positive displacement | 9.50 | 2.78 | 11.60 | 3.40 | -- | -- |
| | Reciproc. | 9.90 | 2.90 | 12.00 | 3.51 | -- | -- |
| Compressor and condenser units 65,000 Btu/hr (19,000 watts) and over[2] | Positive displacement | 9.50 | 2.78 | 12.50 | 3.66 | 12.50 | 3.66 |

### HYDRONIC HEAT PUMPS

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

1- When tested at the standard rating conditions specified in Table No. 5-9.

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

TABLE NO. 5-7

HVAC SYSTEM HEATING EQUIPMENT (HEAT PUMPS)
ELECTRICALLY OPERATED STANDARD RATING CONDITIONS

| CONDITIONS | | TYPE AIR SOURCE | | WATER SOURCE |
|---|---|---|---|---|
| Air entering equipment | dF | 70DB | 70DB | 70DB |
| Outdoor unit ambient | dF | 47DB/43WB | 17DB/15WB | -- |
| Entering water temp. | dF | -- | -- | 60 |
| Water flow rate | | -- | -- | As used in cooling |

Standard ratings are at sea level.

TABLE NO. 5-8

HVAC SYSTEM EQUIPMENT,
ELECTRICALLY DRIVEN
STANDARD RATING CONDITIONS--COOLING

| | | TEMPERATURES | | | |
|---|---|---|---|---|---|
| | | DB | WB | INLET | OUTLET |
| Air entering equipment | dF | 80 | 67 | -- | -- |
| Condenser ambient (air cooled) | dF | 95 | 75 | -- | -- |
| Condenser water (water cooled) | dF | -- | -- | 85 | 95 |

Standard ratings are at sea level.

TABLE NO. 5-9

APPLIED HVAC SYSTEM COMPONENTS
ELECTRICALLY DRIVEN STANDARD RATING CONDITIONS--COOLING

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

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

## TABLE NO. 5-10

## MINIMUM PIPE INSULATION

| PIPING SYSTEM TYPES | FLUID TEMP. RANGE, F | INSULATION THICKNESS IN INCHES FOR PIPE SIZES[1] | | | | | |
|---|---|---|---|---|---|---|---|
| | | RUN OUTS - 2" | 1" & less | 1.25" -2" | 2.5" - 4" | 5" -6" | 8"& lar. |
| **HEATING & HOT WATER SYSTEMS** | | | | | | | |
| Steam & hot water | | | | | | | |
| High pressure/temp | 306-450 | 1.5 | 2.5 | 2.5 | 3.0 | 3.5 | 3.5 |
| Med pressure/temp | 251-305 | 1.5 | 2.0 | 2.5 | 2.5 | 3.0 | 3.0 |
| Low pressure/temp | 201-250 | 1.0 | 1.5 | 1.5 | 2.0 | 2.0 | 2.0 |
| Low temperature | 100-200 | .5 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| Steam condensate (for feed water) | Any | 1.0 | 1.0 | 1.5 | 2.0 | 2.0 | 2.0 |
| **COOLING SYSTEMS** | | | | | | | |
| Chilled water | 40-55 | .5 | .5 | .75 | 1.0 | 1.0 | 1.0 |
| Refrigerant/brine | Below 40 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 |

1- For piping exposed to exterior air, increase thickness by .5".
2- Runouts not exceeding 12 feet in length to individual units.

TABLE NO. 5-11
LIGHTING POWER BUDGET

| OCCUPANCY GROUP | OCCUPANCY DESCRIPTION | LIGHTING POWER BUDGET (watts/ft²) |
|---|---|---|
| A-1 | Assembly w/stage: occupancy of 1000+ | 1.1 |
| A-2 | Assembly w/stage! occupancy < 1000 | 1.1 |
| A-2.1 | Assembly w/o stage, occupancy of 300 or more other than B-2 and E | 1.1 |
| A-3 | Assembly w/o stage: occupancy of less than 300 other than B-2 and E | 1.1 |
| | Drinking and dining establishment | 1.85 |
| A-4 | Stadiums, reviewing stands and amusement park structures not included in A or B-1, B-2 and B-3 | 1.1 |
| A-5 | Stage Lighting | Exempt |
| B-1 | Gasoline and service stations: includes the office, waiting room and pump islands plus 5' on each side of the island | 2.0 |
| | Storage garages | 0.3 |
| B-2 | Office buildings, wholesale stores, municipal police and fire stations | 1.5 |
| | Retail stores | |
| | - Less than 1000 ft² | 4.5 |
| | - 1000-6000 ft² | 3.5 |
| | - 6000-20,000 ft² | 2.5 |
| | - over 20,000 ft2 | 1.5 |
| | Drinking and dining establishments: occ load of less than 50 | 1.85 |
| | Work shops using material not highly flammable or combustible | 2.0 |
| | Storage and warehouses | 0.7 |
| B-3 | Aircraft hangars | 0.7 |
| | Open parking garages | 0.3 |
| B-4 | Ice plants, power plants, pumping plants, cold storage and creameries | 1.0 |
| | Factories and workshops | 2.0 |
| | Storage | 0.7 |
| | Sales rooms | 2.0 |
| | Shipyard structures | 0.7 |
| E-1 | Schools and day-care centers | 2.0 |
| E-2 | Audio-visual presentation lighting | Exempt |
| H-1 | Storage | 0.7 |
| | Handling | 2.0 |

TABLE NO. 5-11 (continued)
LIGHTING POWER BUDGET

| OCCUPANCY GROUP | OCCUPANCY DESCRIPTION | LIGHTING POWER BUDGET (watts/ft²) |
|---|---|---|
| H-2 | Storage | 0.7 |
| | Handling, dry cleaning plants, paint stores | 2.0 |
| | Paint shops and spray painting rooms | 2.5 |
| H-3 | Warehouses | 0.7 |
| | Other | 2.0 |
| H-4 | Auto repair and body shops | 2.0 |
| | Paint spray booths | 5.0 |
| H-5 | Aircraft repair hangars | 2.0 |
| I-1 | Institutions | 2.0 |
| I-2 | Administrative support services | 2.0 |
| I-3 | Nursing areas | 2.0 |
| I-4 | Diagnostic, treatment, food service task lighting | Exempt |
| R-1 | Dwelling unit portions | Exempt |
| | Other than dwelling unit portions | Refer to app.occ. |
| R-3 | Dwelling unit portions | Exempt |
| | Other than dwelling unit portions | Refer to app.occ. |

# CHAPTER 6

# BUILDING DESIGN BY PRESCRIPTIVE REQUIREMENTS APPROACH

**(This chapter is revised in its entirety.)**

## SECTION 601

## SCOPE

### 601.1 General

The provisions of this Chapter are applicable only to low rise R-1 and R-3 Occupancy buildings, and other buildings less than 5000 sq. ft., that use electric energy for heating and/or cooling. The building shall comply with all the requirements of Chapter 5 except for the modifications herein specified.

## SECTION 602

## BUILDING ENVELOPE REQUIREMENTS

### 602.1 General

The building envelope requirements of this Chapter may be met by installing one of the prescriptive packages in Tables No. 6-1, 6-2, 6-3 for low-rise R-3 Occupancy or 6-4 for low-rise R-1 and other buildings less than 5000 sq.ft. Installed components shall meet the following requirements:

### 602.2 Roof/ceiling.

Ceilings below vented attics and vaulted ceilings shall be insulated to not less than the nominal R-value specified for ceilings in Tables No. 6-1, 6-2, 6-3, or 6-4, as applicable. Advanced framing shall require that the nominal R-value be maintained to the outside of the exterior building envelope.

### 602.3 Exterior walls (Above grade).

Above grade exterior walls shall be insulated to not less than the nominal R-value specified in Tables No. 6-1, 6-2, 6-3, or 6-4, as applicable. The R-value shall be the total value for insulation in stud cavities and/or insulated sheathing. Advanced framing shall consist of a minimum of 2x studs at 24" o.c. and two stud corners. Headers shall be insulated with rigid insulation of a minimum nominal R-value of R.4/inch.

**602.4 Exterior walls (Below grade).**

Below grade exterior walls surrounding conditioned space shall be insulated to not less than the nominal R-value specified for below grade walls in Tables No. 6-1, 6-2, 6-3, or 6-4 as applicable.

**602.5 Slab-on-Grade Floors.**

Slab-on-Grade floors shall be insulated along their perimeter to not less than the nominal R-value specified for slab-on-grade floors in Tables No. 6-1, 6-2, 6-3, or 6-4 as applicable.

**602.6 Floors Over Unconditioned Space.**

Floors over unconditioned enclosed spaces, such as vented crawl spaces, unconditioned basements, and parking garages that are not mechanically ventilated shall be insulated to not less than the nominal R-value shown for floors over unconditioned spaces, enclosed area in Tables No. 6-1, 6-2, 6-3, or 6-4 as applicable.

Floors over unconditioned spaces exposed to exterior ambient conditions such as building overhangs, open parking areas and enclosed parking areas which are mechanically ventilated shall be insulated to not less than the nominal R-value shown for unconditioned spaces, exposed area Table No. 6-4.

**602.7 Exterior Doors.**

**602.7.1** All exterior doors shall comply with the infiltration specifications set forth in Table No. 5-3.

**602.7.2** Exterior doors without glazing shall have the maximum U-value shown in Tables No. 6-1, 6-2, 6-3 and 6-4.

**EXCEPTIONS:** 1. Insulated metal doors which are 1-3/4 inches thick shall be deemed to have a nominal U-value of .19; provided that they are thermally broken, have their cores filled with urethane, polystyrene, polyisocyanurate foam or approved equal.

2. Wood doors which are 1-3/4 inches thick shall be deemed to have a nominal U-value of .4; provided that they have solid cores and do not have panels less than 1-1/8 inches thick.

**602.8 Glazing.**

**602.8.1** The total glazed area shall not exceed the percentage of gross floor area specified in Tables No. 6-1, 6-2, 6-3 or 6-4 as applicable.

**602.8.2** All glazing shall have a tested U-value not greater than that specified in Table No. 6-1, 6-2, 6-3 or 6-4 as applicable.

**EXCEPTIONS:** 1. Glazed areas up to a maximum of 4 square feet may be exempted from the thermal transmittance (U) value requirement.

2. Skylights and glazing in exterior doors which exceed the U-value specified for glazing in Tables No. 6-1 through 6-4 as applicable may be installed provided their area is doubled when calculating compliance with the maximum glazing area requirements.

3. Permanently installed insulated shutters or shades with a maximum U-value of 0.2 (R-value of five) may be used to achieve U values of 0.40 or lower when installed in combination with glazing having a maximum U value of 0.50.

**602.8.3** Effective solar glazing shall not be less than the percentage of gross floor area specified in Tables No. 6-1, 6-2 or 6-3 as applicable and shall comply with all requirements of this section.

**602.8.3.1** The glazing area shall be oriented within 45 degrees of true south with no more than 60 percent of the area facing between 31 and 45 degrees of true south.

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

**602.8.3.3** The glazing shall give a transmission coefficient greater than or equal to 0.80 for visible light or greater than equal to 0.73 for total solar radiation for a single pane.

**602.8.3.4** Documentation in the form of a sun chart, photograph or other approved evidence demonstrating that the glazing area oriented within 30 degrees of true south shall not be shaded for at least 3 hours between the hours of 10:00 a.m. and 2:00 p.m. standard time on January 21 and March 21.

**602.8.3.5** An easement or other means of guaranteeing solar access is filed with the building department.

**602.8.4. Thermal Mass.** Thermal mass required for option III in Table No. 6-1, 6-2 and 6-3 shall comply with the following minimum requirements.

**602.8.4.1.** Thermal mass shall be distributed in the floors, walls and/or ceiling and shall be directly exposed to the conditioned space.

**EXCEPTIONS:** 1. Thermal mass covered by finish materials with a combined R-value no greater than 1.0

2. Storage mediums not within the space containing the qualifying glazing shall be provided with an approved natural or mechanical means of transferring the heat to the heat storage medium.

**602.8.4.2.** The heat storage capacity shall be a minimum of 10 Btu/ f-hr per sq. ft. of conditioned floor area.

**602.8.4.3.** The heat storage capacity shall be calculated using EQ 6.1 or standard engineering practice.

HS = D x SH x V...................... Equation 6.1

**WHERE:**

HS = Heat Storage. The heat storage capacity available inside the insulated space.
V = Volume of heat storage components.
D = Density of material inside the insulated shell of the building to a depth yielding a thermal resistance of R=1, except in the case of slab floors where only the slab itself is credited. Mass located in conditioned or unconditioned basements without solar glazing shall not be counted. (lbs/cu.ft.)

## SECTION 603

## AIR LEAKAGE

The minimum air leakage control measures shall be those specified for the prescriptive package shown in Tables No. 6-1, 6-2, 6-3, or 6-4 as applicable.

## SECTION 604

## BUILDING MECHANICAL SYSTEMS

**604.1 Heat Pump.** Air-to-air, ground-to-air, or water-to-air heat pumps installed to comply with a prescriptive package set forth in Tables No. 6-1, 6-2, and 6-3 as determined by an analysis consistent with Section 5.2 of RS-22.

**EXCEPTION:** Air-to-air heat pumps which are listed in the Air Conditioning and Refrigeration Institute's (ARI) Directory of Certified Unitary Air-Conditioners, Unitary Air Source Heat Pumps and Sound Rated Outdoor Equipment as having HSPF of 6.8 Btu/watt or greater and a Low Temperature Coefficient of Performance (COP) of not less than 2.0 shall be considered to comply with the requirements of Tables 6-1, 6-2, and 6-3.

TABLE NO. 6-1
LOW RISE R-3 OCCUPANCIES
COMPONENT PRESCRIPTIVE OPTIONS FOR ZONE 1

| COMPONENT | | OPTIONS | | | |
|---|---|---|---|---|---|
| INSULATION MINIMUM NOMINAL R-VALUE | | I | II | III | IV |
| Ceiling[1] | Flat | R38 | R38 | R38 | R38 |
| | Vaulted | R38 | R38 | R38 | R38 |
| Wall[1] | | R19A | R24A | R19 | R19 |
| Below grade walls | Interior | R19 | R19 | R19 | R19 |
| | Exterior | R10 | R10 | R10 | R10 |
| Floor over unconditioned space | | R30 | R19 | R19 | R19 |
| Slab on grade perimeter | | R10 | R10 | R10 | R10 |
| DOORS: Maximum U-value | | .19 | .19 | .19 | .22 |
| GLAZING: | | | | | |
| Maximum tested U-value | | .40 | .40 | .50 | .60 |
| Maximum glazing area (% of floor) | | 15% | 15% | 18% | 15% |
| Minimum effective solar glazing area | | -- | -- | 10% | -- |
| Minimum thermal mass[2] | | -- | -- | 10 | -- |
| HEAT PUMP MINIMUM HSPF | | -- | -- | -- | 6.8 |
| AIR LEAKAGE CONTROL[3] | | Std | Std | Std | Std |

"-" indicates no requirement
1- A indicates advanced framing.
2- Minimum thermal mass in Btu/°F-ft$^2$.
3- Std. indicates Standard Air Leakage Control. See Section 502.4

NOTE: Each of the prescriptive options is intended to describe a building with a specific feature as noted below:

Option I Base Case
Option II Well Insulated Walls
Option III Passive Solar
Option IV Heat Pump

TABLE NO. 6-2
LOW RISE R-3 OCCUPANCY
COMPONENT PRESCRIPTIVE OPTIONS FOR ZONE 2

| COMPONENT | | OPTIONS | | | |
|---|---|---|---|---|---|
| INSULATION MINIMUM NOMINAL R-VALUE | | I | II | III | IV |
| Ceiling[1] | Flat | R38 | R49A | R38 | R38 |
| | Vaulted | R38 | R38 | R38 | R38 |
| Wall[1] | | R24A | R19A | R19 | R19 |
| Below grade walls | Interior | R19 | R19 | R19 | R19 |
| | Exterior | R12 | R12 | R12 | R12 |
| Floor over unconditioned space | | R30 | R30 | R30 | R30 |
| Slab floor perimeter | | R10 | R10 | R10 | R10 |
| DOORS: Maximum U-value | | .19 | .19 | .19 | .22 |
| GLAZING: | | | | | |
| Maximum tested U-value | | .40 | .40 | .40 | .50 |
| Maximum glazing area (% of floor) | | 15% | 15% | 18% | 15% |
| Minimum effective solar glazing area | | -- | -- | 10% | -- |
| Minimum thermal mass[2] | | -- | -- | 10 | -- |
| HEAT PUMP MINIMUM HSPF: | | -- | -- | -- | 6.8 |
| AIR LEAKAGE CONTROL[3] | | Std | Std | Std | Std |

"-" indicates no requirement
1- A indicates advanced framing.
2- Minimum thermal mass in Btu/°F-ft$^2$.
3- Std. indicates Standard Air Leakage Control. See Section 502.4.
NOTE: Each of the prescriptive options is intended to describe a building with a specific feature as noted below:

Option I Base Case
Option II Well Insulated Walls
Option III Passive Solar
Option IV Heat Pump

TABLE NO. 6-3
LOW RISE R-3 OCCUPANCY
COMPONENT PRESCRIPTIVE OPTIONS FOR ZONE 3

| COMPONENT | | OPTIONS | | | |
|---|---|---|---|---|---|
| INSULATION MINIMUM NOMINAL R-VALUE | | I | II | III | IV |
| Ceiling[1] | Flat | R49A | R38 | R38 | R38 |
| | Vaulted | R38 | R38 | R38 | R38 |
| Wall[1] | | R26A | R30A | R24 | R19 |
| Below grade walls | Interior | R19 | R19 | R19 | R19 |
| | Exterior | R15 | R15 | R15 | R15 |
| Floor over unconditioned space | | R30 | R30 | R30 | R30 |
| Slab floor perimeter | | R10 | R10 | R10 | R10 |
| DOORS: Maximum U-value | | .19 | .19 | .19 | .22 |
| GLAZING: | | | | | |
| Maximum tested U-value | | .40 | .40 | .40 | .40 |
| Maximum glazing area (% of floor) | | 15% | 15% | 18% | 15% |
| Minimum effective solar glazing area | | -- | -- | 10% | -- |
| Minimum thermal mass[2] | | -- | -- | 10 | -- |
| HEAT PUMP MINIMUM HSPF: | | -- | -- | -- | 6.8 |
| AIR LEAKAGE CONTROL[3] | | Std | Std | Std | Std |

"-" indicates no requirement
1- A indicates advanced framing.
2- Minimum thermal mass in Btu/°F-ft².
3- Std. indicates Standard Air Leakage Control. See Section 502.4.
NOTE: Each of the prescriptive options is intended to describe a building with a specific feature as noted below:

Option I Base Case
Option II Well Insulated Walls
Option III Passive Solar
Option IV Heat Pump

TABLE NO. 6-4
LOW-RISE R-1 OCCUPANCIES AND
OTHER OCCUPANCIES LESS THAN 5000 SQ FT
COMPONENT PRESCRIPTIVE STANDARDS

| COMPONENT | | CLIMATE ZONE 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|---|
| | | OPT A | OPT B | OPT A | OPT B | OPT A | OPT B |
| INSULATION MINIMUM NOMINAL R-VALUE | | | | | | | |
| Ceiling1 | Flat | R38 | R38 | R38 | R38 | R49A | R49A |
| | Vaulted | R38 | R38 | R38 | R38 | R38 | R38 |
| Wall[1] | | R19A | R19 | R24A | R24 | R26A | R26 |
| Below grade wall | Interior | R19 | R19 | R19 | R19 | R19 | R19 |
| | Exterior | R10 | R10 | R12 | R12 | R12 | R12 |
| Floor over uncond. space | | | | | | | |
| | Enclosed | R30 | R30 | R30 | R30 | R30 | R30 |
| | Exposed | R38 | R38 | R38 | R38 | R38 | R38 |
| Slab floor perimeter | | R10 | R10 | R10 | R10 | R10 | R10 |
| DOORS: Maximum U-value | | .19 | .19 | .19 | .19 | .19 | .19 |
| GLAZING: | | | | | | | |
| Maximum tested U-value | | .40 | .50 | .40 | .50 | .40 | .50 |
| Maximum glazing area (% of floor) | | 15% | 11% | 15% | 11% | 15% | 11% |
| AIR LEAKAGE[2] | | Std | Std | Std | Std | Std | Std |

"-" indicates no requirement
1- A indicates advanced framing.
2- Std. indicates Standard Air Leakage Control. See Section 502.4.

# CHAPTER 7

## BUILDING DESIGN BY COMPONENT POINT SYSTEM
(This is an entirely new chapter)

## SECTION 701

## SCOPE

### 701.1 General

The provisions of this Chapter are applicable only to low rise R-3 Occupancies that use electric energy for heating and/or cooling. Buildings shall comply with all the requirements of Chapter 5 except for the modifications herein specified.

## SECTION 702

## CALCULATION PROCEDURE

### 702.1 Compliance

The component point system allows modification of the prescribed conservation levels specified in Table No. 5-1 of Chapter 5.

For each building component, the corresponding point value of that component shall be taken from Table No. 7-1 through 7-6 as applicable. Negative points correspond to increased energy requirements, and positive points to reduce requirements. For components which comply with the base case conservation level, the point value will be zero. Calculations shall comply with the procedures listed herein.

**EXCEPTION:** No trade-off shall be permitted for below grade walls or slab on grade. The minimum R-values shall be as specified in Table No. 6-1, 6-2 or 6-3 as applicable, for the base case condition.

Buildings shall be deemed to comply with requirements of this Chapter if the total point value for all components is greater than or equal to zero.

### 702.2 Calculation Procedure

**702.2.1 Components with Multiple Conservation Levels.** Points for cases of multiple conditions for a given component shall be calculated as an area weighted average.

$P = [A_1P_1 + A_2P_2 + \ldots]/A$

WHERE:

$P$ = weighted average component points

$P_1, P_2, \ldots$ = points for component condition 1, 2,....

$A_1, A_2, \ldots$ = area of component for condition 1, 2,....

$A$ = total component area.

**702.2.2 Interpolation of Point Values.** Component construction types which fall between the conservation levels included in Table No. 7-1 through 7-6 may be linearly interpolated.

TABLE NO. 7-1
CEILING POINTS

Flat Ceilings

| Nominal R-Value | Zone 1 Std | Zone 1 Adv | Zone 2 Std | Zone 2 Adv | Zone 3 Std | Zone 3 Adv |
|---|---|---|---|---|---|---|
| 19 | -53 | -43 | -72 | -59 | -128 | -113 |
| 30 | -14 | -2 | -19 | -2 | -65 | -46 |
| 38 | 0 | 14 | 0 | 19 | -43 | -21 |
| 49 | 11 | 26 | 15 | 36 | -25 | 0 |
| 60 | 17 | 35 | 24 | 48 | -15 | 14 |

Vaulted Ceilings

| Nominal R-Value | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| 19 | -71 | -96 | -114 |
| 25 | -38 | -52 | -61 |
| 30 | -19 | -27 | -32 |
| 38 | 0 | 0 | 0 |
| 45 | 11 | 15 | 17 |
| 49 | 21 | 29 | 35 |

TABLE NO. 7-2
ABOVE GRADE WALLS POINTS
(W/WO INSULATION SHEATHING)

| | | Single Stud Walls | | | | | |
|---|---|---|---|---|---|---|---|
| | | Zone 1 | | Zone 2 | | Zone 3 | |
| Nominal | Sheathing | Framing | | Framing | | Framing | |
| R-Value | R-Value | Std | Adv | Std | Adv | Std | Adv |
| 11 | 4 | -20 | -15 | -67 | -60 | -90 | -82 |
| | 5 | -11 | -7 | -54 | -49 | -75 | -68 |
| | 6 | -3 | 1 | -43 | -38 | -62 | -56 |
| | 7 | 4 | 8 | -33 | -29 | -50 | -45 |
| | 8 | 11 | 13 | -25 | -21 | -40 | -35 |
| | 9 | 16 | 19 | -17 | -14 | -31 | -27 |
| | 10 | 21 | 24 | -10 | -7 | -22 | -19 |
| | 11 | 26 | 28 | -4 | -1 | -15 | -12 |
| | 12 | 30 | 32 | 2 | 5 | -8 | -5 |
| 13 | 4 | -9 | -4 | -52 | -45 | -72 | -63 |
| | 5 | -1 | 4 | -41 | -34 | -59 | -51 |
| | 6 | 6 | 10 | -31 | -25 | -48 | -41 |
| | 7 | 12 | 16 | -23 | -18 | -37 | -31 |
| | 8 | 18 | 21 | -15 | -10 | -28 | -23 |
| | 9 | 23 | 26 | -8 | -4 | -20 | -15 |
| | 10 | 27 | 30 | -2 | 2 | -13 | -8 |
| | 11 | 31 | 34 | 4 | 7 | -6 | -2 |
| | 12 | 35 | 37 | 9 | 12 | 0 | 4 |
| 19 | 0 | -16 | 0 | -62 | -40 | -83 | -57 |
| | 1 | -6 | 7 | -48 | -30 | -67 | -46 |
| | 2 | 2 | 13 | -37 | -21 | -54 | -36 |
| | 3 | 9 | 19 | -27 | -13 | -42 | -27 |
| | 4 | 16 | 24 | -18 | -6 | -32 | -18 |
| | 5 | 21 | 29 | -11 | 0 | -23 | -11 |
| | 6 | 26 | 32 | -4 | 5 | -15 | -4 |
| | 7 | 30 | 35 | 2 | 9 | -8 | 0 |
| | 8 | 34 | 40 | 8 | 15 | -1 | 7 |
| | 9 | 38 | 43 | 13 | 20 | 4 | 12 |
| | 10 | 41 | 45 | 17 | 24 | 10 | 17 |
| | 11 | 44 | 48 | 22 | 27 | 15 | 21 |
| | 12 | 47 | 51 | 26 | 31 | 19 | 25 |
| 22 | 0 | -5 | 11 | -47 | -24 | -66 | -39 |
| | 1 | 4 | 18 | -35 | -15 | -51 | -29 |
| | 2 | 11 | 23 | -24 | -8 | -39 | -20 |
| | 3 | 18 | 28 | -15 | -1 | -29 | -12 |
| | 4 | 23 | 32 | -8 | 5 | -20 | -5 |
| | 5 | 28 | 36 | -1 | 10 | -12 | 1 |
| | 6 | 32 | 39 | 5 | 15 | -5 | 7 |
| | 7 | 36 | 43 | 11 | 19 | 2 | 12 |
| | 8 | 40 | 45 | 16 | 24 | 8 | 17 |

TABLE NO. 7-2 (continued)
WALLS (ABOVE GRADE) POINTS

Single Stud Walls

| Nominal R-Value | Sheathing R-Value | Zone 1 Framing Std | Zone 1 Framing Adv | Zone 2 Framing Std | Zone 2 Framing Adv | Zone 3 Framing Std | Zone 3 Framing Adv |
|---|---|---|---|---|---|---|---|
| 22 | 9 | 43 | 48 | 20 | 27 | 13 | 22 |
| | 10 | 46 | 51 | 24 | 31 | 18 | 26 |
| | 11 | 49 | 53 | 28 | 34 | 22 | 29 |
| | 12 | 51 | 55 | 32 | 37 | 27 | 33 |

Double Stud Walls

| Nominal R-Value | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| 30 | 46 | 24 | 18 |
| 33 | 56 | 39 | 35 |
| 38 | 63 | 48 | 46 |
| 41 | 67 | 54 | 53 |

Strap Walls

| Nominal R-Value | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| 27 | 31 | 3 | -7 |
| 30 | 37 | 12 | 4 |

TABLE NO. 7-3
FLOORS OVER UNCONDITIONED SPACES POINTS

| Nominal R-Value | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| 11 | -60 | -82 | -96 |
| 19 | -24 | -33 | -39 |
| 25 | -9 | -12 | -14 |
| 30 | 0 | 0 | 0 |
| 38 | 11 | 15 | 17 |

TABLE NO. 7-4
DOOR POINTS

| Description | Zone 1 | Zone 1 with Storm | Zone 2 | Zone 2 with Storm | Zone 3 | Zone 3 with Storm |
|---|---|---|---|---|---|---|
| Metal, solid urethane core flush w/TB | 0 | 1 | 0 | 2 | 0 | 2 |
| Metal, 1-1/8" panel urethane core TB | -2 | 1 | -3 | 1 | -4 | 1 |
| Metal, ureth core flush TB w/double glass | -5 | -1 | -7 | -2 | -8 | -2 |
| Metal, 1-1/8" pnl ureth TB w/dbl glass | -7 | -2 | -9 | -3 | -11 | -4 |
| Wood, solid core flush | -10 | -4 | -14 | -6 | -17 | -7 |
| Metal, ureth core flush TB w/single glass | -12 | -5 | -16 | -7 | -19 | -8 |
| Wood, solid core flush w/dbl glass | -13 | -6 | -18 | -8 | -21 | -10 |
| Metal, 1-1/8" pnl ureth TB w/sngl glass | -13 | -6 | -18 | -8 | -21 | -10 |
| Wood, 1-1/8" panel | -15 | -7 | -20 | -9 | -24 | -11 |
| Wood, 1-1/8" panel w/ dbl glass | -18 | -9 | -25 | -12 | -29 | -14 |
| Wood, solid core flush w/sngl glass | -20 | -10 | -27 | -13 | -32 | -15 |
| Wood, hollow core flush | -20 | -10 | -27 | -13 | -32 | -15 |
| Wood, 7/16" panel w/ dbl glass | -23 | -11 | -31 | -15 | -36 | -18 |
| Wood, 7/16" panel | -26 | -13 | -35 | -17 | -41 | -20 |
| Wood, hollow core flush w/sngl glass | -27 | -13 | -37 | -17 | -43 | -20 |
| Wood, 1-1/8" panel w/ sngl glass | -31 | -14 | -42 | -19 | -49 | -22 |
| Wood, 7/16" panel w/ sngl glass | -35 | -16 | -47 | -22 | -56 | -26 |

TABLE NO. 7-5
GLAZING POINTS

Glazing Percentage (% of Floor Area)

| U Value | Zone 1 9% | Zone 1 12% | Zone 1 15% | Zone 1 18% | Zone 2 9% | Zone 2 12% | Zone 2 15% | Zone 2 18% | Zone 3 9% | Zone 3 12% | Zone 3 15% | Zone 3 18% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .20 | 63 | 71 | 78 | 83 | 87 | 99 | 107 | 113 | 115 | 122 | 127 | 131 |
| .22 | 58 | 65 | 71 | 74 | 80 | 90 | 97 | 101 | 107 | 112 | 115 | 116 |
| .24 | 53 | 59 | 63 | 65 | 74 | 81 | 86 | 88 | 99 | 101 | 102 | 101 |
| .26 | 48 | 52 | 55 | 56 | 67 | 72 | 75 | 76 | 91 | 91 | 89 | 86 |
| .28 | 43 | 46 | 47 | 47 | 60 | 64 | 65 | 63 | 83 | 80 | 76 | 71 |
| .30 | 38 | 40 | 40 | 38 | 53 | 55 | 54 | 51 | 75 | 70 | 64 | 56 |
| .32 | 34 | 33 | 32 | 29 | 47 | 46 | 43 | 38 | 67 | 60 | 51 | 41 |
| .34 | 29 | 27 | 24 | 20 | 40 | 37 | 32 | 25 | 59 | 49 | 38 | 25 |
| .36 | 24 | 20 | 16 | 10 | 33 | 29 | 22 | 12 | 51 | 39 | 25 | 10 |
| .38 | 19 | 14 | 8 | 1 | 27 | 20 | 11 | 0 | 43 | 29 | 13 | -5 |
| .40 | 14 | 8 | 0 | -9 | 20 | 11 | 0 | -13 | 36 | 18 | 0 | -20 |
| .42 | 9 | 1 | -8 | -18 | 13 | 2 | -11 | -26 | 28 | 8 | -13 | -35 |
| .44 | 4 | -5 | -16 | -28 | 7 | -7 | -22 | -39 | 20 | -2 | -25 | -50 |
| .46 | -1 | -12 | -24 | -37 | 0 | -15 | -33 | -52 | 12 | -12 | -38 | -65 |
| .48 | -6 | -18 | -32 | -47 | -7 | -24 | -43 | -65 | 4 | -23 | -51 | -81 |
| .50 | -11 | -25 | -40 | -56 | -13 | -33 | -54 | -78 | -3 | -33 | -64 | -96 |
| .52 | -15 | -31 | -48 | -66 | -20 | -42 | -65 | -91 | -11 | -43 | -76 | -111 |
| .54 | -20 | -38 | -56 | -75 | -26 | -50 | -76 | -104 | -19 | -53 | -89 | -126 |
| .56 | -25 | -44 | -64 | -85 | -33 | -59 | -87 | -117 | -27 | -64 | -102 | -141 |
| .58 | -30 | -50 | -72 | -94 | -40 | -68 | -98 | -130 | -34 | -74 | -115 | -156 |
| .60 | -35 | -57 | -80 | -104 | -46 | -76 | -108 | -143 | -42 | -84 | -127 | -171 |
| .62 | -40 | -63 | -88 | -114 | -53 | -85 | -119 | -156 | -50 | -94 | -140 | -186 |
| .64 | -45 | -70 | -96 | -123 | -59 | -94 | -130 | -169 | -57 | -104 | -153 | -201 |
| .66 | -50 | -76 | -104 | -133 | -66 | -103 | -141 | -182 | -65 | -115 | -165 | -216 |
| .68 | -54 | -83 | -112 | -143 | -73 | -111 | -152 | -195 | -73 | -125 | -178 | -231 |
| .70 | -59 | -89 | -120 | -152 | -79 | -120 | -162 | -208 | -80 | -135 | -191 | -247 |
| .72 | -64 | -96 | -128 | -162 | -86 | -129 | -173 | -221 | -88 | -145 | -203 | -262 |
| .74 | -69 | -102 | -136 | -171 | -92 | -137 | -184 | -234 | -96 | -155 | -216 | -277 |
| .76 | -74 | -108 | -144 | -181 | -99 | -146 | -195 | -247 | -103 | -165 | -229 | -292 |
| .78 | -78 | -115 | -152 | -191 | -105 | -154 | -205 | -260 | -111 | -176 | -242 | -307 |
| .80 | -83 | -121 | -160 | -200 | -112 | -163 | -216 | -273 | -119 | -186 | -254 | -321 |

TABLE NO. 7-6

AIR LEAKAGE CONTROL W/HEAT RECOVERY VENTILATION POINTS

| Air Leakage Control* | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| Standard | 0 | 0 | 0 |
| Advanced | 59 | 76 | 87 |

* See Section 502.4.

# CHAPTER 8

## STANDARDS

801.1

The standards and portions thereof, which are referred to in various parts of this code shall be part of the Model Energy Code and are hereby declared to be a part of this code.

| CODE STANDARD NO. | TITLE AND SOURCE |
|---|---|
| RS-1 | 1985 ASHRAE Handbook of Fundamentals |
| RS-2 | Standard Method of Test for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors, Specification E283-73 of ASTM. |
| | Specifications for Aluminum Windows, ANSI A134.1, 1972<br>Specifications for Aluminum Sliding Glass Doors, ANSI A134.2, 1972. |
| | Industry Standard for Wood Window Units, NWMA IS-2, Industry Standard for Wood Sliding Patio Doors, NWMA IS-3. |
| RS-2B | AAMA 1503.1, 1980 Voluntary Test Method for Thermal transmittance of windows, doors and glazed wall sections. |
| RS-2C | ASTM C236 test for thermal conductance and transmittance of built-up sections by means of a guarded hot box; and ASTM C976 thermal performance of building assemblies by means of the calibrated hot box. |
| RS-3 | ASHRAE Standard 62-81 Ventilation for acceptable indoor air quality. |
| RS-4 | ASHRAE Standard 55-74 Thermal Environmental Conditions for Human Occupancy. |
| RS-5 | DOE Test Procedures for Water Heaters, 10 CFR Part 430 Appendix E to Subpart B. |
| R-6 | Household Automatic Electric Storage-Type Water Heaters, ANSI C72.1-1972. |

| | |
|---|---|
| R-7 | Gas Water Heaters, Volume III, Circulating Tank, Instantaneous and Large Automatic Storage-Type Water Heaters, ANSI Z21.10.3, 1974. |
| RS-8 | IES Lighting Handbook, 6th Edition, 1981 Illuminating Engineering Society. |
| RS-9 | ASHRAE Standard 90A-1980, Energy Conservation in New Building Design. |
| RS-10 | Standard for Packaged Terminal Air Conditioners, ARI Standard 310-70. |
| RS-11 | 1984 ASHRAE Systems Handbook. |
| RS-12 | Energy Calculations I: Procedures for Determining Heating and Cooling Loads for Computerizing Energy Calculations--Algorithms for Building Heat Transfer Subsystems, ASHRAE 1975. |
| RS-13 | Energy Calculations II: Procedures for Simulating the Performance of Components and Systems for Energy Calculations, 3rd Edition, ASHRAE 1975. |
| RS-14 | Standard for Positive Displacement Refrigerant Compressor and Condensing Units, ARI Standard 520-74. |
| RS-15 | 1983 ASHRAE Equipment Handbook. |
| RS-16 | Heating and Air Conditioning Systems--Installation Standards, SMACNA, February, 1977. |
| RS-17 | SMACNA Low Pressure Duct Construction Standards, 5th Edition, Washington, D.C., 1976. |
| RS-18 | SMACNA High Pressure Duct Construction Standards, 3rd Edition, Washington, D.C., 1975. |
| RS-19 | SMACNA Fibrous Glass Duct Construction Standards, 5th Edition, Washington, D.C., 1979. |
| RS-20 | 1982 ASHRAE Handbook and Product Directory, Applications Volume. |
| RS-21 | Standard for Package Terminal Heat Pumps, ARI Standard 380-78. |
| RS-22 | ASTM E779-781 Standard practice for measuring air leakage by the fan pressurization method. |

RS-23 ASTM E741 Standard practice for measuring air leakage by the tracer dilution method.

RS-24 Standard 24 CFR Part 3280 HUD.

## ACCREDITED AUTHORITATIVE AGENCIES

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

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

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

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

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

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

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

NWMA refers to the National Woodwork Manufacturers Association, Inc., 400 Madison Ave., Chicago, IL 60606

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

# NORTHWEST ENERGY CODE STANDARD NO. 25

## Ventilation System Installation Standards

## 1.0 SCOPE

These specifications established the minimum ventilation system requirements for design and installation. R-3 occupancies complying with the provisions of standard air leakage control (Section 502.4.3 NWEC) shall comply with the provisions of Section 3.0 as a minimum or may also comply with the provisions of Section 4.0 or Section 5.0. Buildings complying with the provisions of advanced air leakage control (Section 502.4.4) shall comply with the provisions of Section 4.0 or Section 5.0.

## 2.0 DEFINITIONS

- **AAHX:** Abbreviation for an air-to-air heat exchanger.

- **AAHX System:** All components associated with the AAHX installation.

- **Air, Exhaust:** The air stream flowing from the mechanical ventilation device to the atmosphere, consisting of stale indoor air; air removed from a space and not reused therein.

- **Air, Flow distribution:** The distribution of air within the conditioned space.

- **Air, Indoor:** Air contained inside conditioned space.

- **Air, Intake:** The air stream passing from the exterior of the house to the mechanical ventilation device, consisting of outdoor air.

- **Air Makeup:** Outside air supplied to replace exhaust air.

- **Air, Outdoor:** Air taken from the external atmosphere and, therefore, not previously circulated through the system.

- **Air, Return:** The air stream passing from the mechanical ventilation device to conditioned space, consisting of outdoor air.

- **Air, Supply:** The air stream passing from the mechanical ventilation device to conditioned space, consisting of outdoor air.

- **Air, Tempered:** Air taken from the external atmosphere that has been warmed.

- **Balanced System (whole-house):** Balanced means a ventilation system in which the flow rate of the exhaust air leaving the building is equal to the supply airflow rate entering the building, as measured at the AAHX within +20 percent using balancing equipment and procedures specified by a certified AAHX system designer or manufacturer's testing equipment.

- **Calibrated Flow Measurement Devices:** Devices which provide for measurement of mass flow performed in accordance with the Air Movement and Control Association's Standard 210.

- **Central System:** System designed to deliver and to exhaust air, in a distribution throughout the house, and connected to a central air movement system.

- **Cold Side:** The air streams going to and from the outdoors, to and from the mechanical ventilation device.

- **Combined Living Areas:** Rooms with one half of the area of the common walls open and unobstructed and provides an opening of not less than one tenth of the floor area of the interior room or 25 square feet, whichever is greater.

- **Damper:** A device used to vary the volume of air passing through an air outlet, inlet, or duct.

- **Diffuser:** A terminal device designed to supply air to the conditioned space.

- **Exchanger, Air-to-Air Heat (AAHX):** A device in which heat is transferred between two air streams.

- **Exhaust Air Heat Pump (EAHP):** A heat pump system that is designed and used to ventilate the interior envelope of a building and provide a reintroduction of energy in the form of potable hot water or potable hot water and space heating.

- **Flow Balanced System:** A ventilation system designed to avoid an excessive indoor/outdoor pressure differential by incorporating both supply and exhaust fans which can be adjusted for flow balancing.

- **Flow Rate:** The rate of air flow expressed in cubic feet per minute.

- **Flow System Unbalanced:** A ventilation system in which the flow rates of the exhaust air leaving the building are not equal to the supply air entering the building. This type of system produces a negative building pressure in which the interior air pressure is less then the exterior air pressure.

- **Free Area:** Unobstructed area for airflow through a grill, register, or hood.

- **Grille:** An air terminal device used to supply or remove air from a conditioned space.

- **Hard Wire:** Wired directly from the electrical junction box without the use of a plug or receptacle.

- **Habitable Room:** A space or room designed for human occupancy, such as a bedroom, living room, dining room, kitchen, family room, recreation room, or den.

- **Hoods:** Exterior wall terminals for the air intake and the exhaust air flows.

- **NWEC:** The Northwest Energy Code promulgated by BPA.

- **Pressure Balanced System:** A ventilation system designed to avoid excessive indoor negative pressure by incorporating one or more passive air inlets in conjunction with exhaust fans.

- **Pressure Drop:** Static pressure loss in fluid pressure (as from one end of a duct to the other, due to friction, dynamic losses, and changes in velocity pressure).

- **Readily Accessible:** Available to the average person in order to maintain, and be accessible without the use of tools or ladders.

- **Registers:** An air terminal device with a built-in damper.

- **Sone:** The sone is equal in loudness to a pure tone of 1,000 cycles per second at 40 decibels above the listener's threshold of hearing.

- **Supply:** See air, supply.

- **Ventilation:** The process of supplying and removing air by natural or mechanical means to and from any space. Such air may or may not be conditioned.

- **Ventilation, Continuous:** A continuous supply of outside air at the specified minimum rate achieved at least 23 hours per day.

- **Ventilation, Net:** The total supply airflow adjusted by the amount of cross leakage to determine the net fresh air supply.

- **Ventilation Rate (VR):** The total volume of air introduced into a conditioned space per unit time. (Specifically: cubic feet per minute (CFM).

- **Warm Side:** The air streams going to and from the conditioned space, to and from the mechanical ventilation device.

## 3.0 NON-HEAT RECOVERY MECHANICAL VENTILATION SYSTEMS

3.1 **Scope.** This section applies to the design and installation of non-heat recovery ventilation systems for individual dwelling units that are capable of providing a minimum rate of ventilation air to the whole-house and an increased ventilation rate, on an intermittent basis, for exhausting indoor contaminants in kitchens and bathrooms (spot ventilation), when required. Buildings using advanced air leakage control may not use non-heat recovery ventilation.

3.2 There are four design methods for achieving whole-house and spot ventilation capacity:

a. **Integrated Spot and Whole House Design:** This system uses one or more of local ventilation fans to provide whole house ventilation. Fresh air inlets in bedrooms and undercut doors shall provide the air circulation of fresh air through the house to the localized fan.

b. **Ducted Central Exhaust Design:** This system uses a single large multi-speed exhaust fan ducted to bedrooms, baths, kitchen and living areas to provide both whole-house and spot ventilation. The fan is controlled to provide a high speed, high flow exhaust when needed for spot ventilation in the kitchen or bathrooms. The fan also operates at a lower flow rate when controlled to provide whole house ventilation.

c. **Discrete Spot and Whole-House Design:** This system uses separate fans and control systems to provide spot and whole house ventilation.

d. **Forced Air Heating/Cooling System Integrated Design:** In this system spot ventilation is provided through bath and kitchen exhaust fans but whole house ventilation and make up air are provided through integration with the forced air heating/cooling system.

3.3 **Design and Installation Requirements:**

a. **System Sizing:** A mechanical ventilation system shall be sized to provide the quantities of exhaust ventilation specified in section 502.1.8 **NWEC.**

b. **Whole House Fan Ratings:** Fans used to provide whole house ventilation shall be rated for noise and airflow as follows:

1. **Noise:** All fans used to provide whole-house ventilation shall have a tested sone rating of 2.5 or less. The noise rating shall be tested at the rated capacity operated at 0.1 inches of static pressure. This rating may be exceeded if the fan is remotely

located from the space being ventilated.

2. **Airflow:** The fan capacity shall be rated output at 0.1 inches of static pressure.

c. **Backdraft Dampers:** A tight-fitting backdraft damper shall be provide in each exhaust duct and capable of closing when the fan is not in use.

d. **Ductwork:**Ductwork connected to the whole house fan shall be installed with minimum bends and shall be of minimum size per the following table:

| AIRFLOW (CFM) | DIAMETER (inches) |
|---|---|
| less than or equal to 50 | 3.5 |
| from 50 to 100 | 5 |
| more than 100 | 6 |

In climate zones 2 and 3, provisions shall be made to deal with condensation and frost build-up in ducts located outside the conditioned space.

e. **Controls:** Each ventilation system shall have controls for both the spot ventilation fans and the whole house fans that meet the following requirements:

1. Spot ventilation in baths shall be controlled by crank timers, dehumidistats, light switches, or as approved. Spot ventilation in kitchens should be controlled by dehumidistat or crank timers but may be controlled by a manual switch.

2. The whole house fan shall be controlled to operate on an automatic basis and to allow manual operation if desired. The automatic control system shall be based upon humidity levels (dehumidistat) or time (time of day timers or cycle timers) or as approved. The whole house fan shall also be connected to a manual override switch that allows the occupant to turn the fan on continuously or to disable the system if desired.

f. **Makeup Air:**

1. **General:** The minimum makeup air to be provided shall be equal to the number of sleeping room times 10 cfm plus an additional 10 cfm.

The makeup air requirement may be provided by fresh air ports. Flow controlled ports designed to provide fresh air installed in each room requiring make up air: or, central makeup air ducts: A central duct providing makeup air directly to the return plenum of a forced air heating/cooling system and a circulating fan circulates the fresh air to the required rooms (used with Forced Air Heating/Cooling System Integrated Design).

2. **Source:** The source for fresh air makeup shall be located to minimize the potential to draw outdoor air pollutants inside during whole house fan operation. The source shall also be located to minimize the potential for excessive outdoor noise levels being transmitted to the interior through the makeup air system.

3. **Protection:** The source for makeup air shall have adequate provisions on the exterior connection to protect the system against entry by insects, birds, leave, or other such objects.

4. **Mixing/Tempering:** Provisions shall be made to temper the make up air before it is allowed to enter the occupied zone. This may be achieved by drawing makeup air in through long thin slots to mix with room air, direct heating, drawing through a buffered space, or as approved.

5. **Flow Control:** The makeup air source shall have provisions for flow control to limit excessive air flows under normal operation.

6. **Distribution:** Adequate provisions to ensure distribution of the makeup air to the necessary rooms and to the appropriate whole house fans shall be made such as undercut doors, ducted exhaust ports, exhaust air plenums. etc.

3.4 **Operation Check:** The following items will be verified by the system installer.

a. Exhaust airflow and Makeup airflow.
b. Controls are provided and verified to operate according to approved design.
c. Equipment Identification.
d. Operation and maintenance are available at ----------------.

## 4.0 AIR-TO-AIR HEAT EXCHANGERS

4.1 **Scope:** This specification applies to the design and installation of air-to-air heat exchange systems capable of meeting ventilation requirements of Section 502.1.8 NWEC while providing heat recovery. Spot ventilation requirements for baths and kitchens may be met through the Air to Air Heat Exchanger or by separate exhaust fans.

4.2 **System Design and Installation:**

a. **General:** The AAHX shall be specifically designed for use in residential buildings, and shall be capable of ventilating the conditioned space by introducing outdoor air and exhausting indoor air. The outdoor air shall be conditioned through an exchange of heat from the indoor air that is being exhausted to the outside of the building.

The overall ventilation rate of any dwelling unit using mechanical ventilation capacity and natural air leakage shall be a minimum of 0.35 air changes per hour (ACH). Buildings complying with the provisions of Advanced Air Leakage Control shall be sized based on the assumption that the natural air leakage rate for dwellings is 0.1 ACH for the purpose of calculating the mechanical ventilation capacity.

b. **System Design:**

1. **General:** Systems shall be sized and designed to provide the design air change rate to the conditioned spaces at the registers according to one of the following methods:

**Prescriptive Method:** The system shall be sized according to the provisions of Section 4.2(c) Prescriptive Sizing Method, or,

**System Design Method:** The entire system shall be designed and sized for each house submitted using the calculated pressure loss or the equivalent length method by an approved designer. The system design shall include complete duct friction loss calculations, AAHX unit fan pressure/flow curves, register and grill pressure drops. Documentation including all f the above information shall be available for review upon request.

2. **Delivered Capacity:** As an overall system,

including all ductwork and registers, the AAHX system shall be designed to be capable of providing a minimum installed mechanical ventilation capacity of 0.25 ACH to the conditioned space when run continuously. The maximum installed capacity shall be 0.35 ACH when run continuously. AAHX systems using inline duct heaters to provide space conditioning may exceed the 0.35 ACH capacity limit.

The AAHX system may exceed 0.35 ACH in capability if the system is being used for bath and kitchen exhaust ventilation requirements set forth elsewhere. However, the system shall only exceed the maximum delivered capacity for purposes of exhausting these spaces.

3. **Type:** The AAHX system shall at a minimum be a BPA approved central system type. It shall also comply with the uniform building and uniform mechanical codes.

4. **Supplies:** There shall be an air supply to each bedroom and one additional habitable conditioned space.

5. **Returns:** There shall be, at least, one return within the conditioned space. If there are no exhaust fans in the kitchen, bathroom, or utility areas, then there shall be one return located in each of those spaces, allowing the AAHX to serve as the exhaust system.

6. **Sound Attenuation:** Vibration arrestors shall be installed per manufacturer's recommendations. Flex duct shall be included between the unit and the supply duct. Acoustical isolation shall be provided between adjacent rooms

c. **Prescriptive Sizing Method:** This section provides a method for sizing central system AAHXs and the associated ductwork for a minimum installed capacity without performing detailed calculations on each system.

If the system does not conform to all of the provisions of this section, then it must be designed according to the Complete System Design Method in Section 4.2(b).

System Requirements: All of the following conditions will be satisfied for each AAHX before the system and ductwork can be sized.

1. **Floor Area:** Each unit shall comply with the requirements of Table 4-1. It shall not handle a floor area in excess of 3000 sq ft.

2. **Balancing:** The stale air and fresh airflow streams include balancing dampers to allow for balancing within 10 percent.

3. **Exhaust Branch Duct Runs:** A minimum of one and a maximum of four stale air exhaust branch duct runs are included in the system.

4. **Supply Branch Duct Runs:** A minimum of three and a maximum of five fresh air supply branch duct runs are included in the system.

5. **Straight Duct Run Length:** A maximum duct run length of 100 feet of straight duct from the outside hoods to any of the inside registers.

6. **Main Branch Elbows:** A maximum of six 90 degree elbows or bends or twelve 45 degree elbows or bends from the outside intake or exhaust hood to the main duct run between the AAHX and the first branch for either the fresh or stale air duct runs.

7. **Branch Duct Elbows:** A maximum of six 90 degree elbows or bends or twelve 45 degree elbows or bends from the first branch off the main duct run to any register for either the fresh or stale air duct runs.

8. **AAHX Minimum Design Flow Rate:** The AAHX from the approved list shall be capable of providing the design flow rate of 0.25 ACH at 0.3 inches of water equivalent external pressure drop.

Table 4-1

**Design Flow Rate and Duct Size by Conditioned Floor Area**

| Conditioned Floor Area (square feet) | Design Flow Rate (cfm) | Minimum Duct Size Flex (in) | Minimum Duct Size Smooth (in) |
|---|---|---|---|
| 200 | 7 | 3 | 2 |
| 400 | 13 | 4 | 3 |
| 600 | 20 | 4 | 3 |
| 800 | 27 | 5 | 4 |
| 1000 | 33 | 5 | 4 |
| 1250 | 42 | 5 | 4 |
| 1500 | 50 | 5 | 4 |
| 1750 | 58 | 6 | 5 |
| 2000 | 67 | 6 | 5 |
| 2250 | 75 | 6 | 5 |
| 2500 | 83 | 7 | 6 |
| 2750 | 92 | 7 | 6 |
| 3000 | 100 | 7 | 6 |

d. **Unit Location:** The AAHX unit shall be located in a conditioned space, or as approved. The AAHX unit shall be located and installed in such a manner so that controls, filters, exchanger cores, condensate removal equipment and wiring are all readily accessible for routine maintenance and removal. The AAHX shall be located and installed to minimize noise.

e. **System Control Strategy:**

1. **General:** Control system design and installation shall comply with all local electrical codes and be capable of operating the unit continuously. all controls shall be labeled as to function and operation.

2. **Power:** A separate power circuit shall be provided for the AAHX and the unit which shall be hard wired to that circuit if the listing so states.

3. **Dehumidistat:** There shall be a dehumidistat in the system located in the general living area away from the major humidity sources. The dehumidistat shall increase the ventilation rate when activated, and shall be adjustable from 30 percent to 80 percent

relative humidity ± percent.

4. **On/Off Switch:** A listed on/off switch shall be installed and accessible to the occupant. The switch shall be clearly marked to indicate its "on" position. The on/off switch shall be located next to the dehumidistat sensing device and control. If multiple switches are used to control the unit, each switch shall independently control the unit without interfering with any other switches.

5. **Variable Speed Control:** Variable speed operation or high/low speed setting shall be provided for the AAHXs that are being used to meet the exhaust requirements for baths and/or kitchens, but is not necessary on the AAHX unit that is specifically designed to run in a constant "on" mode and which has the capability to provide 0.35 ACH (including basements).

f. **Ducts and Distribution System:**

1. Ducts shall be located within the enclosed areas of the dwelling.

2. Ducts shall not be located in exterior wall cavities.

**EXCEPTION:** Ducts may be located in exterior wall cavities if a minimum of 2-inch exterior rigid foam plastic insulation can be placed between the duct and the outside wall surface.

3. Warm side ducts that are located in unconditioned spaces shall be insulated to not less than R-4.

4. Cold side intake and exhaust ducts leading from the unit shall have an exterior vapor barrier plus a minimum of R-4 insulation. Return ducts in unconditioned spaces as well as exhaust ducts shall have interior vapor barriers.

5. Uninsulated ductwork shall not be buried in the attic or floor insulation.

**EXCEPTION:** Uninsulated duct runs located in attics or floors may be insulated by covering the duct with an equivalent level of insulation as required for the floor/ceiling or roof/ceiling provided that the duct is located either in the joist cavities or is resting directly on the joists. Ducts stacked on other ducts shall not be allowed to be insulated by floor/ceiling insulation.

6. Ducts shall be designed and installed to minimize pressure drop. Duct runs shall be installed with minimum change in direction and a minimum length of material.

7. Ductwork shall be supported adequately to prevent unnecessary bends and sags. Strapping and support of ductwork shall be installed as per the Uniform Mechanical Code and manufacturer's specifications. Use of duct tape or similar materials for support and strapping shall not be permitted.

8. All ducts shall have a minimum nominal interior diameter as determined by the prescriptive sizing requirements or as determined by the system design.

9. If prescriptive sizing requirements are used, air intake grilles shall have a minimum free area of 36 square inches for each 100 CFM of design airflow at the air intake. Air outlet grilles shall have a minimum free area of 30 square inches for each 100 CFM of design airflow at the exhaust hood.

10. For AAHX's without preheated supply air, all supply diffusers installed in frequently occupied rooms shall be designed for air-conditioning use, shall be ceiling outlets or high-wall diffusers, and shall be installed in accordance with manufacturer's recommendations. Supply diffusers installed in rarely occupied and less thermally sensitive areas may use air distribution systems that minimize air velocity to reduce drafts in lieu of air-conditioning design.

11. Adjustable, tamper-proof registers shall be provided.

12. Balancing dampers shall be installed on the warm side of the unit on both air streams, within 2 feet of the unit, or an approved alternative that assures incoming/outgoing flows are within 10 percent of each other. Air distribution adjustment from

room-to-room may require additional balancing dampers. If the AAHX unit is capable of running in an unbalanced mode for defrost purposes with an imbalance of no more than 50 percent more airflow in the exhaust stream than in the intake air stream.

13. Outside intake and exhaust shall be located at least 6 feet from each other, and shall not be located by driveways, carports, or areas where contaminated air is likely to exist. All hoods shall be a minimum of 12 inches above finished grade and should be protected from environmental degradation. Intake and exhaust hoods shall incorporate 1/4-inch mesh screen or the equivalent. Intake hoods shall be located at least 6 feet away from clothes dryers, kitchen and bathroom exhaust fan hoods, and shall not be located on roofs. The outside hood shall have a backdraft damper.

g. **Condensate:**

1. Condensate removal piping and equipment shall be designed and installed according to the manufacturer's specifications.

2. Condensate removal piping equipment design and installation shall comply with all applicable State and local codes.

3. The condensate lines shall be installed in a space where the temperature is maintained above the freezing point.

h. **Filters:**

1. The AAHX shall have a particulate filter located on the return duct upstream from the AAHX which is adequate to prevent contamination of the AAHX core from general airborne dust.

2. The AAHX shall also have a filter sufficient to remove the majority of pollens and other aeroallergens, and be located on the intake stream to the AAHX. The intake air filter shall be readily accessible for maintenance.

3. Filters shall be installed in accordance with the manufacturer's instructions.

4. One set of clean air filters shall be left

with the unit for replacement by the occupants.

4.3 **Duct Heaters:** All heating devices used to condition airflows in the AAHX system including duct heaters or terminal reheaters shall comply with the provisions of this Section.

a. **Local Codes:** The installation shall comply with all local building, electrical and mechanical codes.

b. **Unit Listing:** The duct heater shall be UL listed, CSA approved, or have an approved equivalent safety certification.

c. **Ducts:** Sheet metal or approved ducting shall be used for a minimum of 5 feet downstream and 1-foot upstream of the duct heating unit.

d. **Airflow Capacity:** Airflow capacity of the AAHX shall meet the following requirements:

1. Match duct heater specifications.
2. Not allow duct temperature rises which exceed 67 degrees F, and
3. Be able to maintain suitable duct temperatures for occupant comfort.

e. **Airflow Distribution:** Provisions shall be made to assure even airflow across heater elements.

f. **Duct Heater Size:** The duct heater shall have a thermal output capacity of no greater than 125 percent of the whole-house design heating load.

g. **Controls:** A feedback sensing control and/or a manual override on/off switch shall be provided that prevents the house from overheating and/or prevents entry of cold air supply.

h. **Labels:** There shall be instructional labels on all controls.

i. **Accessibility:** The duct heater shall be easily accessible for repair or replacement.

j. **System Design:** If a non-packaged system is used, then a registered professional engineer shall approve the system design.

k. **Manuals:** Duct heater systems shall be accompanied by an installation manual and a homeowner manual describing the operation of the heater in conjunction with the AAHX and the operation of all controls and safety features.

4.4 **Forced Air Furnace Integration:** systems designed and installed to use the forced air heating system ducting for distribution of supply air shall comply with the provisions of this section.

a. **Exhaust Ducts:** A separate stale air exhaust duct system shall be installed to the AAHX according to the provisions of Section 5.2 System Layout.

b. **Supply Duct:** The AAHX fresh air supply shall be ducted to within 12 inches of an undampered return grille of the forced air heating system. the supply duct shall not be directly connected to the undampered return grille of the forced air heating system.

**EXCEPTION:** Direct connection may be allowed if specified as a recommended installation by the manufacturer and as approved by the participating utility.

c. **Forced air Return Grille Size:** The area of the return air grille where the AAHX supply air is ducted to shall be at least 150 percent of the area of the AAHX fresh air supply duct.

d. **Location:** The AAHX and the opening in the return grille shall be located in a conditioned space.

e. **Fan Control:** The forced air heating system fan control shall allow for two-speed operation including a low speed for continuous fresh air distribution as well as the normal high speed for heating. The low speed setting shall be designed for continuous operation without affecting occupant comfort.

f. **Flow Control:** Dampers shall be provided to allow a flow balanced system.

4.5 **Operation Check:**

a. **System Operation:**

1. The installer shall certify that the AAHX

system operates as designed. The actual flow delivered to the conditioned space shall meet the design flow within 10 percent.

2. All control devices shall function as intended.

b. **System Balancing:**

1. the installer shall balance the system by measuring total volumetric airflow in both flow paths using calibrated flow measuring device and by adjusting balancing dampers and/or supply register dampers to obtain equal flow rates (± 10 percent) in both the supply and exhaust airflow paths.

2. a means of balancing airflow in branch ducts shall be provided where necessary.

c. **Airflow Measurement:** the airflow rates into the house from each supply register shall be measured and adjusted, if possible, to provide an even ventilation pattern throughout the house.

d. **Wiring:** All of the control wiring and power wiring connections shall be thoroughly checked out at startup.

e. **Controls:** The installer shall provide the homeowner with a description of the control setup for the AAHX system. The description shall explain the various control devices and indicate an initial setpoint. It shall also describe the purpose behind each control and suggest methods for adjusting setpoints to obtain an acceptable ventilation rate.

f. **Manufacturer Information:**

1. the installer shall provide the homeowner with a complete set of the manufacturer-supplied information which accompanied the AAHX.

2. The installer shall affix all manufacturer-supplied caution, maintenance, operation, etc., labels to the proper location on the system.

3. The installer shall provide the homeowner with a written manufacturer's warranty.

4. the installer shall provide the homeowner with

the name, address and phone number of the nearest manufacturer's representative, and/or the nearest equipment service center.

g. **Labeling:**

1. The four ducts attached to the AAHX shall be labeled as to the function.

2. All controls shall be labeled.

h. **Certification:**

1. the installer shall certify completion of the installation and correct airflow/balancing adjustments by completing a form approved by BPA.

2. The installer shall certify that a complete set of manuals providing clear instructions and sizing information for installation and operation for the householder to perform routine maintenance was provided.

3. The installer and recipient shall sign the form. A copy shall be provided to the homeowner/builder and the manufacturer of the AAHX.

## 5.0 EXHAUST AIR HEAT PUMP (EAHP) VENTILATION SYSTEM

5.1 **Scope:** This specification applies to the design and installation of exhaust air heat pump systems for individual dwelling units. Buildings complying with the provisions of advanced air leakage control shall comply with all of the provisions of this chapter or Section 4.0 Air-to-Air heat Exchangers. Spot ventilation requirements for baths and kitchens may be met through the exhaust air heat pump system or through separate exhaust fans.

5.2 **Design and Installation Requirements:**

a. **System Design:** the exhaust air heat pump system shall be specifically designed for use in residential buildings and shall be capable of ventilating the conditioned space by extracting air from indoors and providing for the introduction of outdoor air.

The primary function of the EAHP system will be to provide ventilation inside a closed building by extracting interior air and running it through a properly sized heat pump to reclaim the exhausted heat energy in the form of potable hot water.

A properly sized heat pump is a unit that is designed to maintain the minimum ventilation rate as required and is capable of supplying all of the domestic hot water needs.

Secondary space heating is an option that may be used in conjunction with the water heater. If the space heating option is to be used, the electrical resistance element in the hot water heater shall be disabled during the space heating mode.

b. **Ventilation Rate:** The control system shall be designed to be capable of maintaining the minimum ventilation rate required.

c. **Resistance Backup:** A resistance backup coil shall be provided and shall be sized to be capable of supplying the hot water demand load when the heat pump ventilation system is not in operation.

d. **Location:** The EAHP system shall be located in a readily accessible conditioned space, acoustically isolated, and protected against freezing. Ease of maintenance and service shall be a major consideration when locating the heat pump unit. The system shall be placed in such a location as to optimize operating efficiency and that duct runs from the EAHP are as short as possible, minimizing bends and restrictions, and in facilitating placement of supply and return points.

e. **Supply and Return Points:** The EAHP system shall be designed in such a manner as to provide whole-house ventilation and heat recovery. At a minimum, supply shall be provided to each bedroom and one general living area. There shall be at least one centrally located return point. If separate exhaust fans are not installed in baths and kitchens, the EAHP shall provide a return in each bath and kitchen. Returns in kitchens shall not be placed over ranges.

f. **Interior Vents:** All air supply and return points within the house shall be covered with register/grilles and shall be located to reduce the possibility of airflow short circuit between the supply/return lines. air supply registers shall be located in the ceiling or high on wall surfaces to provide maximum supply of airflow with minimum discomfort and shall direct the airflow parallel to the floor/ceiling surfaces or upward toward the ceiling. Return grilles shall have flow control dampers.

g. **Exterior Vents:**

1. **Hoods:** Intake and exhaust hoods shall be at least 12 inches above the finish grade. The air intake inlets are recommended to be located on the south side of the building but not to be located by a driveway or carport. Hoods shall be resistant to environmental degradation and shall be labeled as to their proper function (e.g., 'exhaust air'). Other locations may be accepted as approved.

2. **Outside Vents:** The outside air intake vents shall be separated from the outside exhaust vents by at least 6 feet unless properly designed intake and exhaust nozzles allow back-to-back placement with no possible crossflow contamination.

3. **Backdraft Damper:** A backdraft damper shall be installed in the outside exhaust hood. both intake and exhaust hoods shall be turned downward to prevent rain and snow entry and located where ice formation will not cause safety problems.

h. **Duct Layout and Design:** Ducts shall be sized and designed according to standard engineering practice. Duct installation shall meet all State and local building codes for safety and construction. ducting shall have duct joints and seams sealed with tape or similar means. Ductwork from the heat pump to the outside exhaust shall be installed to provide adequate drainage of condensation.

i. Duct Insulation shall comply with the requirements of Section 4.2(e).

j. **Filters:** filters shall be installed upstream of the exhaust air heat pump equipment in both the intake and return airducts and insect screens shall be installed at all outside intake and exhaust points.

k. **Condensation:** A condensation drain shall be provided for the heat pump so that any possible overflow of moisture will be piped to a suitable drain and all building codes are met. Any piping used for condensate control shall be within a conditioned space and shall direct condensate to a non-freezing drain.

5.3 **Operation Check:**

a. **Certification:** The equipment shall be certified in accordance with the Gas Appliance manufacturer's Association approved equivalent.

b. **Warranty:** The heat pump unit shall be provided with a 1-year written warranty on parts, a homeowner manual, and installation instructions.

c. **Installer Verification:** The system installer shall verify that the system operates as designed. the installer shall complete a form containing the following items: Verification of Airflow, Controls, Equipment Identification, Brochures and Operation and Maintenance.

**References:** The following documents are not all specifically referenced in this specification but are listed to provide additional sources of information regarding ventilation system design and installation.


- Underwriters Laboratory Inc., Standard (ULI)
  181-1987 - Factory-made Airducts and Connectors
  883 - Fan Coil Units and Room-Fan Heater Units.
  507 - Electric Fans.

- Uniform Mechanical Code 1985

- National Electric Code 1985

- Uniform building Code 1985

- Canadian Standards Association (CSA) Preliminary Standard C439-M1985 Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators

- Canadian Standards Association (CSA) C444 -M1985 Installation Guidelines for Heat Recovery Ventilators

- Canadian Standards Association (CSA) C22.2 No. 113-M1984 Fans and Ventilators

- American Society of Heating, Refrigeration and

Airconditioning Engineers (ASHRAE) Standard 62-81, Ventilation for Acceptable Indoor Air Quality

- American Society of Heating, Refrigeration and airconditioning Engineers (ASHRAE) Standard 62-81, Ventilation for Acceptable Indoor Air Quality

- Home Ventilating Institute, Division of AMCA, Heat Recovery Ventilator's Product Certification Procedure, Heat Recovery Ventilator's Performance Test Standard for Ducted Heat Recovery Ventilators

- Air Movement and Control Association (AMCA) 210 Laboratory Methods of Testing Fans for Rating.

- Bonneville Power Administration: Air to Air Heat Exchanger Product Specifications (NWEC Standard #26)

# NORTHWEST ENERGY CODE STANDARD NO. 26

## Bonneville Power Administration
## Air-to-Air Heat Exchangers
## Product Specifications

## 1.0 SCOPE

This specification covers self-contained central air-to air heat exchangers made of factory-assembled components in which heat is transferred between two isolated airstreams.

## 2.0 PURPOSE

The purpose of this specification is to establish minimum material and performance requirements for central air-to air heat exchangers. This specification establishes minimum acceptable levels of performance based on the test procedure in Section 7.0.

## 3.0 DEFINITIONS

For the purpose of this specification, the following terms are defined:

- **Air-to-Air Heat Exchanger (AAHX):** A device used to ventilate the conditioned space by exhausting indoor air and supplying fresh air and which transfers heat between two isolated airstreams.
- **Bonneville:** Bonneville Power Administration.
- **Manufacturer:** Person or persons which assemble the elements or components of the air-to-air heat exchanger.
- **MCS Programs:** Model Conservation Standard support programs.
- **Net Ventilation:** The volume of air introduced into the conditioned space per unit time.

## 4.0 REFERENCES

Referenced standards are as follows:

Heat Recovery Ventilator Performance Testing Standard for Ducted Heat Recovery Ventilators, Home Ventilating Institute (HVI), 1987 edition.

## 5.0 GENERAL REQUIREMENTS

5.1 These specifications are intended to comply with applicable existing codes and Federal regulations. In any case where a Federal, State or local code or regulation exceeds the requirements herein, that code or regulation shall apply.

5.2 Air-to-air heat exchangers installed under MCS Programs shall meet the criteria defined in this specification. The Manufacturer shall be responsible for submitting to Bonneville or its designated representative the test information for evaluation prior to installation. Once accepted under MCS Programs, the product shall be approved without resubmittal to Bonneville except as noted in Paragraph 5.3. The unit shall also be proven to comply with uniform building and uniform mechanical code requirements.

5.3 Bonneville reserves the right to identify and disapprove for use in MCS Programs, any product at any time when it is deemed the product is not satisfactory for future use in MCS Programs. Such disapproval shall be issued in writing and shall identify the flaws found in the product. Disapproval shall be issued after consultation with the manufacturer.

## 6.0 PRODUCT REQUIREMENTS

6.1 The air-to-air heat exchangers supplied shall be specifically designed for use in residential buildings. The unit shall be rated for voltage which is nominally available in a single family residence. Power shall be supplied to the unit through Underwriter Laboratories' (UL) or Canadian Standards Associations' (CSA) or approved equal listed three conductor wire (one conductor is ground) either permanently wired or through the use of UL listed electrical cord and a three-prong plug.

6.2 The motor(s) shall be matched to the blower(s) and the conditions under which the blower(s) operates. The motor(s) shall be listed by UL, CSA or approved equal. The motor(s) and blower(s) shall be permanently lubricated.

6.3 The air-to-air heat exchanger including a defrost mode shall be listed by Underwriter Laboratories (UL) or Canadian Standards Association (CSA) or approved equal.

6.4 The components of the air-to-air heat exchanger shall be easily accessible for routine maintenance. The motor(s), blower(s), filter(s), and controls shall be accessible without removing the unit, detaching the ductwork, or using special tools.

6.5 The air-to-air heat exchanger shall have a method of condensate removal that results from the operation of the heat exchanger. This shall be accomplished using a drain system or a comparable mechanism.

## 7.0 TEST REQUIREMENTS

7.1 The air-to-air heat exchanger shall have test data from an approved independent testing agency. Tests shall be conducted in accordance with Heat Recovery Ventilator Performance Testing Standard for Ducted Heat Recovery Ventilators, Home Ventilating Institute (HVI), 1987. For each product to be approved, the above test shall demonstrate compliance with the following criteria:

| Factors | Supply Air Temperature (F) | System Pressure (in W.G.) | Net Air Flow Rate (CFM) | Acceptance Criteria |
|---|---|---|---|---|
| Net Supply Airflow Rate | 32 | 0.2 | | Min 50 CFM |
| Exhaust Air Transfer Ratio | 32 | 0.2 | | Max 0.10 |
| Sensible Recovery Efficiency | 32 | | 50 | Min 0.65 |
| Low Temp. Ventilation Reduction Factor: | | | | |
| Supply | | | | Min 0.85 |
| Exhaust | | | | Min 0.85 |

7.2 The air-to-air heat exchanger shall have tested air flow rates of standard air to within +/- 15% CFM, whichever is greater, of manufacturer's designed flow rates on both supply and exhaust streams.

## 8.0 DOCUMENTATION

8.1 The Manufacturer or his distributor shall provide to the consumer a warranty in writing against manufacturing defects for a period of at least one year. The unit shall be shipped with a written warranty which is understandable to the Consumer.

8.2 The Manufacturer shall provide two Operation and Maintenance instructions with the product, one written for the installer and one written for the consumer. Simple and clear instructions shall include:

1. Range of outdoor temperatures at which the unit is designed to operate,
2. Installation and start-up instructions including options,
3. Recommended operation instructions with air filter description,
4. Routine maintenance instructions with air filter description,
5. Trouble-shooting instructions for minor problems,
6. Component and accessory list, model identification information, and
7. Name, address and telephone number of the Manufacturer or Distributor authorized to service the product.

8.3 The air-to-air heat exchanger shall be identified with the Manufacturer's name and model name or number.

8.4 The source and direction of air flow shall be permanently identified on each of the four duct connections for proper installation and maintenance.

APPENDIX

# RADON MITIGATION SPECIFICATIONS

## SECTION 901

## SCOPE AND DEFINITIONS

**901.1 Purpose**

The purpose is to establish minimum criteria for the design and installation of radon reduction systems based on monitored radon concentrations in R-3 occupancies which comply with the NWEC. The mitigation requirements will not be required unless a monitoring of the soil around or under the building indicates the presence of radon gas.

**901.2 Definitions.**

**Isolated Basement.** A basement that is physically separated or capable of being separated from the upper floors of the building. This includes basements with stairwells to upper floors with a closeable door at the upper floor, and penetrations in the basement ceiling which are sealed against air leakage to the upper floors.

**Net Free Ventilation Openings.** The net area of unencumbered vent (i.e., the gross area subtracting the area of screens or louvers) which provides free air access.

**Permeability, Low.** Permeability is considered low when the soil conditions are poorly drained.

**Permeability, High.** Permeability is considered high when the soil conditions are well-drained.

**Pressure Field.** A system of underslab or underground piping which is used to create a pressure gradient underneath the slab.

**Sone.** The sone is equal in loudness to a pure tone of 1,000 cycles per second at 40 decibels above the listener's threshold of hearing.

## SECTION 902

## GENERAL REQUIREMENTS

**902.1 General.**

Residential buildings that do not comply with section 502.1.7.2 shall monitor for the presence of radon gas in accordance with Section 903. Those buildings in which a reading of more than 5 PCi/l shall have a radon reduction system designed, installed and monitored to reduce the concentration to a level of 50% of the initial reading.

> **EXCEPTION:** Buildings complying with the applicable Section 904, 905, or 906 of this chapter.

**902.2 System Labeling.**

**902.2.1** A label shall be affixed to an accessible permanent, indoor location within each individual dwelling unit.

**902.2.2** This label shall inform the homeowner that the house contains a radon mitigation system. The label shall state that more information on the system can be obtained by contacting ___(local utility number)___.

## SECTION 903

## MONITORING FOR RADON GAS

903.1 **Monitor:** Monitoring shall be performed using a Terradex Corporation type SF passive monitor or an approved equal.

903.2 **Monitoring Period:** The radon monitor shall be installed within 12 months of completion of the home for a minimum of three months during the period of September through March or as approved for the monitor being used.

903.3 **Monitoring Location:** The radon monitor shall be installed on the first story in the main living area of the home on an open shelf or other flat surface, or be suspended from the ceiling 4' to 7' above the floor, away from windows and doors, and away from possible drafts from heating or cooling vents.

903.4 **Labeling:** The monitor shall be tagged with a label containing information consistent with the Bonneville Power Administration's Residential Weatherization Program specifications for labeling of radon detectors.

903.5 **Radon Reduction System Requirement Criteria:** After monitoring a radon reduction system shall be installed based upon the monitored radon level and house type as given in Table 9-1.

## SECTION 904

## RADON REDUCTION SYSTEM FOR BUILDINGS WITH BASEMENTS

**904.1 Application Criteria.** This system shall be used only in buildings with a full or partial basement that can be completely isolated from the remainder of the living space and thus be placed under a constant positive pressure condition relative to the outdoor pressure.

**904.2 Construction Requirements.**

**904.2.1 Basement Isolation.** a. Basements shall be isolated from the living space.

b. All holes in the living space floor shall be sealed, including plumbing, electrical, structural supports, etc.

c. All duct work penetration through occupied floor over the basement shall be sealed.

d. All doors separating the basement from the living area shall be weatherstripped.

**904.2.2 Basement Slab Sealing.** Perimeter cracks and control joints shall be caulked.

**904.2.3 Basement Wall Sealing.** a. If the exterior side of the foundation is exposed, the exterior of the foundation shall be damp-proofed and backfilled.

b. The top of hollow block walls shall be sealed with ethafoam sill sealer and butyl caulk.

c. The interior of block walls shall be coated with epoxy paint or parging.

d. All pipes and electrical penetrations shall be sealed with caulk.

**904.2.4** Ventilation shall be by a stand alone pressurization system or forced air system integration shall be provided.

**904.2.5** a. Discrete pressurization system is a permanently installed fan, ducted and controlled to pull air from the upper living areas and exhaust that air into the basement.

The fan shall be listed by an agency, designed for continuous operation, and have a sone rating no greater than 2.5.

b. The system shall be sized to pressurize the basement by supplying fan ventilation to the basement of a greater capacity than the natural air leakage rate of the basement. As a minimum the quantities listed in table 9-2 shall be provided.

**904.2.6 Forced Air Heating System in the Section.** This section only applies to basement pressurization systems which are to be integrated with existing forced air heating systems. a. The forced air heating system shall be a closed-loop system.

b. All air for forced air heating system operation shall be provided from the living space return air system.

c. A supply air outlet to the basement shall be provided.

d. A permanent fan shall be located in the basement supply air outlet to maintain a positive pressure condition relative to the outdoor pressure. It shall be readily accessible for maintenance and replacement.

e. The fan shall operate independent from the forced air heating system.

f. The fan shall have a sone rating of 2.5 or less.
g. The size of the fan shall comply with Table 9-2.
h. The fan shall be hard-wired to a separate circuit breaker in the main electrical panel.

## SECTION 905

## RADON REDUCTION SYSTEM FOR BUILDINGS WITH SLABS-ON-GRADE

### 905.1 Purpose

To provide a slab-on-grade system that effectively reduces radon entry from the soil beneath the slab by establishing a pressure gradient between the soil and the slab.

### 905.2 Construction Requirements.

**905.2.1 Slab Sealing.** Perimeter cracks and control joints shall be caulked.

**905.2.2 Slab Holes.** a. One three foot diameter hole in the slab shall be provided for every 300 to 700 square foot area, depending on the soil permeability.

b. If the soil is of high permeability, a slab hole shall be provided for at least every 700 square foot area. If the soil is of low permeability, a slab hole shall be provided for at least every 300 square foot area.

c. Each slab hole shall be located at least eight (8) feet in any direction from any other slab hole.

d. Each slab hole shall fully penetrate the entire slab depth.

e. After the hole is made in the concrete, the soil below shall be excavated to the diameter of the slab hole to a depth of 1 foot and filled with gravel to the level of the underside of the slab. A layer of asphalted building paper, 6 mil polyethylene film, or an approved equal shall be placed on top of the gravel fill in the hole to prevent concrete from filling the air spaces in the gravel.

f. A 4 inch Schedule 40 PVC pipe long enough to extend 6 inches downward into the gravel and 2 inches upward above the top of the existing slab shall be inserted into the gravel.

g. An even coat of epoxy sealant shall then be applied to the walls of each slab hole. A non-shrinking grout and bonding agent mixture shall be poured into the slab hole around the pipe and on top of the building paper to the level of the original slab floor before the epoxy sealant has completely cured.

**905.2.3 Piping.** a. Piping used above the slab shall be four inch outside diameter, Schedule 40 plastic sewer pipe, or approved equivalent.

b. A pipe shall vertically penetrate the slab in each slab hole in conformance with section 905.2.2 (f) & (g).

c. A finish bead of silicone shall be applied at all pipe/grout joints.

d. A piping system shall connect all vertical pipes and be sealed at the joints non-hardening sealant to like pipe sections to form a continuous airflow path to the outside.

**905.2.4 Ventilation Fan Requirements.** a. An approved, listed exhaust fan, designed for continuous operation, with a sone rating of no greater than four, and capable of moving at least 50 CFM of air against 0.5 inches of static water pressure shall be provided within each pipe system.

b. The direction of air flow in the slab-on-grade system shall be dependent on soil permeability. If soil is of high permeability, air flow shall be directed from the outdoor air into the slab system, thereby pressurizing the area under the slab. If the soil is of low permeability, air flow shall be directed from the slab system into the outside air.

c. All vertical pipes shall be connected and sealed to lie pipe sections to form a continuous air flow path to the outside.

d. All pipe sections shall be sealed at the joints with nonhardening sealant.

e. Fans shall be hard-wired to a separate circuit breaker in the main electrical panel.

f. Exhaust fans shall be located on the exterior end of each pipe system in order to facilitate removal for maintenance or replacement, and protected from the environment and inadvertent human contact.

## SECTION 906

## RADON REDUCTION SYSTEM FOR BUILDINGS WITH CRAWLSPACES

### 906.1 Purpose

To provide crawlspace ventilation system that will reduce the concentration of radon in the crawlspace.

### 906.2 Construction Requirements.

**906.2.1 Application Criteria.** This system shall be developed only in buildings with a full or partial crawlspace. This mitigation system shall not be installed in homes with crawlspace plenum heating systems.

**906.2.2 Crawlspace Isolation.** a. All penetrations in the living space floor above the crawlspace shall be sealed.

b. All ductwork located in the crawlspace shall be sealed.

c. All crawlspaces shall be sealed to be isolated from basements, attached garages, or other adjacent enclosed spaces.

**906.2.3 Crawlspace Ventilation.** As a minimum, it shall comply with the Uniform Building Code. Baffles shall be installed at foundation vent openings to prevent underfloor insulation from interfering with air flow.

**906.2.4 Ventilating Fan Requirements.** a. Fans shall be listed by an approved agency.

b. Fans shall have a sone rating of no greater than four.

c. Each fan shall be capable of providing the minimum flow rates as listed in Table 9-3.

d. Fans shall be designed for continuous operation.

**906.2.5 Ventilating Fan Installation.** a. A ventilating fan shall be hard wired into a separate circuit breaker in the main electrical panel.

b. Fans shall be oriented in such a way that airflow is drawn from the outside of the crawlspace and delivered into the crawlspace or vice versa. The airflow direction is the choice of the installer/homeowner.

c. Where possible, fans shall be located in exterior foundation walls. A large enough crawl space opening shall be provided for maintenance or replacement of the fan.

TABLE 9-1
RADON MITIGATION REQUIREMENTS

| Radon Reading (pCi/l) | House Type | Requirement |
|---|---|---|
| less than or equal to 5 | Any | No requirement. |
| between 5 and 10 | Any | A whole house central system air to-air heat exchanger meeting the requirements of NWEC Standard No. 25 shall be installed. |
| greater than 10, up to 20 | Full Crawlspace | Passive crawlspace ventilation of 1 sq ft net free ventilating area per 75 sq ft of floor area shall be installed. |
| | Full Isolated Basement | An air-to-air heat exchanger meeting the requirements of NWEC Std 25 and sized for the basement area shall be installed in the basement. |
| | Part Crawl-space, part basement | Passive crawlspace ventilation of 1 square foot of net free ventilating area per 75 square feet of floor area shall be installed in the crawlspace. The house shall then be re-monitored for radon. If the re-monitored level does not exceed 50% of the initial monitored level then no additional action is necessary. If the re-monitored level exceeds 50% then an air to air heat exchanger meeting the requirements of NWEC Standard #25 or a basement pressurization system meeting the requirements of Section 904 or a sub-slab system meeting the requirements of Section 905 shall be installed in the basement. |
| | All Others | Heated Plenum Crawlspaces: If the house has a heated crawlspace used as a heating system plenum then ductwork shall be installed to all of the floor registers supplied by |

TABLE 9-1
RADON MITIGATION REQUIREMENTS (CONTINUED)

| Radon Reading (pCi/1) | House Type | Requirement |
|---|---|---|
| greater than 10 up to 20 | All Others Continued | The crawlspace plenum. Passive crawlspace ventilation of 1 square foot of net free ventilating area per 75 square feet of floor area shall be installed in the crawlspace.<br><br>All other Partial Crawlspaces: Passive crawlspace ventilation of 1 square foot of net free ventilating area per 75 square feet of floor area shall be installed in the crawlspace. The building shall then be remonitored for radon. If the re-monitored levels exceed 50% of the original monitored level then a sub-slab system meeting the requirements of Section 905 shall be installed. |
| infinity | Full Crawlspace | An active crawlspace ventilation system shall be installed. |
| | Full Basement isolatable | A slab on grade system complying with Section 905 shall be installed. |
| | Part Crawlspace, part basement | An active crawlspace ventilation system meeting the requirement of 906 shall be installed and the house shall be re-monitored for radon. If the re-monitored results are less than or equal to 50% of the initial monitored level, then a basement pressurization system meeting the requirements of Section 904 or a slab on grade system meeting the requirements of Section 905 shall be installed. |
| | All Others | Heated Plenum Crawlspaces: If the house has a heated crawlspace used as a heating system plenum then |

TABLE 9-1
RADON MITIGATION REQUIREMENTS (CONTINUED)

| Radon Reading (pCi/1) | House Type | Requirement |
|---|---|---|
| | All Others continued | ductwork shall be installed to all of the floor registers supplied by the crawlspace plenum. A crawl-space ventilation system meeting the requirements of Section 906 shall then be installed.<br><br>All Other Partial Crawlspaces: An crawlspace ventilation system meeting the requirements of section 906 shall be installed. The building shall then be remonitored for radon. If the remonitored levels exceed 50% of the original monitored level then a sub slab system meeting the requirements of section 905 shall be installed.<br><br>All other Slab Floors Without Crawlspaces: shall have a slab on grade system meeting the requirements of section 905 installed. |

Table 9-2
**FAN SIZES FOR BASEMENT[1] PRESSURIZATION SYSTEMS**

| Area (sq.ft.) | Flow Rates CFM[2] |
|---|---|
| 250 | 25 |
| 500 | 27 |
| 750 | 40 |
| 1000 | 53 |
| 1250 | 67 |
| 1500 | 80 |
| 1750 | 93 |
| 2000 | 107 |
| 2500 | 133 |
| 3000 | 160 |
| 3500 | 187 |

[1]basement areas at 8' height.
[2]0.4 air change per hour capacity.

TABLE 9-3
**FAN FOR ACTIVE CRAWLSPACE VENTILATION SYSTEMS**

**Flow Rates For Various Crawlspace Areas And Average Heights (CFM)**

| Area-sf | 18" High or less | 24" High | 30" High | 36" High or more |
|---|---|---|---|---|
| 250 | 25 | 25 | 25 | 25 |
| 500 | 25 | 33 | 42 | 50 |
| 750 | 38 | 50 | 62 | 75 |
| 1000 | 50 | 67 | 83 | 100 |
| 1250 | 62 | 83 | 104 | 125 |
| 1500 | 75 | 100 | 125 | 150 |
| 1750 | 88 | 117 | 146 | 175 |
| 2000 | 100 | 133 | 167 | 200 |
| 2500 | 125 | 167 | 208 | 250 |
| 3000 | 150 | 200 | 250 | 300 |
| 3500 | 175 | 233 | 292 | 350 |
| 4000 | 200 | 267 | 333 | 400 |
| 5000 | 250 | 333 | 417 | 500 |

# CHAPTER 10

## OPTIONAL CALCULATION FOR CONNECTED INTERIOR LIGHTING BUDGET

1001.1 **General** This calculation procedure may be used to determine compliance with Section 505.3.2 of this code. It is intended to permit design flexibility in meeting special illumination needs sometimes found in office and sales areas. The interior budget calculated using this procedure may be used when approved by the Building Official.

1001.2 **Optional Calculation for Maximum Interior Connected Lighting Load.** The watts of the building's interior connected lighting load shall be no more than the maximum calculated in Section 1001.2.1. This section shall be used only if the plans and specifications submitted under this Code shows the occupancy and use in each space.

1001.2.1 Calculate the maximum connected lighting load for lighting inside the building envelope as indicated below as a summation of wattage allotments determined for individual areas, rooms, and task locations in the building envelope as shown in the required plans, based on the illuminance category and the room cavity ratio (RCR) calculated as shown in Equation 10.1.

$$RCR = 5H(L + W)/LW \qquad \text{Equation 10.1}$$

B Where:
- RCR = Room Cavity Ratio
- H = Vertical distance from work plane to lighting fixture (FT)
- L = Length of room (FT)
- W = Width of room (FT)

1001.2.1.1 For offices the appropriate illuminance category for each area/activity shall be selected from the Office Lighting American National Standard Practice, ANSI/IES RP-1 1982.

Spaces designated for illuminance category F and higher shall be identified on the plans and specifications submitted under this Code showing locations of individual tasks and equipment to provide illumination of those tasks.

The illuminance category for visual task requirements selected for each task space shall not be based upon an incidental task or combination of tasks which specify use of a given illuminance category or higher when the incidence of these tasks totals less than two hours per working day.

Selection of a higher level illuminance category to accommodate poor quality tasks shall be permitted only if task quality cannot be improved. Task quality may be improved if the equipment or procedure that produces the poor quality task is controlled by the occupant. Tasks with quality that cannot be improved are generated outside of the control of the business of the occupant working with these tasks. a "poor quality task" is a visual task that requires illuminance category "E" or greater and is due to choice of a writing or printing method that produces characters that are of smaller size or lower contrast than good quality alternatives that are regularly used in offices. Poor quality tasks include the following:

Ditto copy
Thermal copy, poor copy
Xerography, 3rd generation or greater
Thermal printer
Impact printer, 2nd carbon or later
Typed print, 2nd carbon or later
Printing 6 pt type
Handwritten carbon copies
Handwritten #4 and harder pencil

Examples of good quality alternatives which are regularly used in offices and which may be selected to replace one of the above poor quality tasks include:

Mimeograph and xerograph copy
Impact printers with good ribbon
Typed originals in 8 pt and larger type
Handwritten originals in #2 pencil or pen

1001.2.1.2 For retail and wholesale stores, the lighting power level for merchandising and associated service areas of stores as defined in Table 1 of the Illuminating Engineering Society Publication, "RP2" Recommended Practice for Lighting Merchandising Areas, shall be the Table 10-1 watts per square foot listed for the illuminance categories shown in Table 10-2.

The watts per square foot value shall be determined as a weighted average of the Table 10-1 values based upon the actual number of displays in each task area/throw distance category.

In areas where luminaries must be at or above 15 foot mounting heights the allotment may be increased by the following multipliers:

Required Mounting Height (feet) Multiplier

| Required Mounting Height (feet) | Multiplier |
|---|---|
| 15 | 1.15 |
| 16 | 1.21 |
| 17 | 1.47 |
| 18 | 1.65 |
| 19 | 1.84 |
| 20 | 2.04 |

Allotments calculated for floor mounted displays and wall mounted displays are separate and any excess wattage above what is actually installed for one may not be added to the allotment of the other.

Areas established for determining feature display allotments need not be excluded from calculation of gross sales area allotment. Feature display allotments are in addition to the gross sales area allotment.

Exceptions:

1. If detailed documentation of actual areas with specific dimensions of al feature displays and each luminaire designated for each of these displays is provided, the feature display allotment may be used up to a maximum of 10 percent of the gross sales area.

2. If very valuable merchandise, not directly accessible to the customer, is presented as feature displays in floor mounted, counter cases that are externally lighted from above; an allotment of 20 watts per square foot times the actual area of lighted case top may be used. Detailed documentation on plans must show actual placement with specific dimensions of enclosed counter display cases and each luminaire designated to provide lighting for each case.

   Note: Very valuable merchandise includes: jewelry, rare coins, small art objects and similar items where selling involves customer inspection of very fine detail from outside of a locked counter case.

Office spaces in retail buildings shall have lighting power allotments based upon provisions of 1001.2.1.1 above.

**1001.2.1.3** For spaces in either office or retail buildings which are not covered by provisions of Section 1001.2.1.1 or (2) above, the appropriate illuminance category shall be selected from the IES Lighting Handbook, 1981 Reference Volume, Appendix A, Figure 2-2.

1001.2.1.4 Calculate the allotted watts for each space by multiplying the square feet of area by the watts per square foot value for the selected illuminance categories A, B, C and D, the entire space is allotted the designated watts per square foot value for the category. For illuminance categories E and F, a task oriented lighting allotment at the designated watts per square foot value for the category is allowed a general lighting allotment at one-third the designated watts per square foot value for the category. For illuminance categories G, H and I, the allotted watts per square foot value for the category shall be allowed for only the actual task area as shown on the plans. For illuminance categories A through F, if values from RCR columns "RCR 3.5 to 7+" are used, calculation of the RCR shall be made from Equation 10-1.

1001.2.1.5 The total allotted watts shall be determined as the summation of allotted watts for all A, B, C, D, E and F illuminance category spaces plus either the allotted watts or actual design watts, whichever is smaller, for each G, H and I illuminance category space.

1001.2.1.6 Multiple allotments for the same space are allowed if two or more distinctly different lighting systems are required for multiple use of the space and are independently circuited and interlocked to permit only one system to be operated at a time.

**1001.2.2 Lighting Controls.** For the purpose of demonstrating compliance with Section 1001.2.1 above, the design lighting watts of the building may be adjusted for lighting controls in accordance with Equation 10.2.

**Equation 10.2**

$$ACLL = \frac{[(W_T - CW_1)(PSAF_1) - (CW_2)(PSAF_2) - \ldots - (CW_n)(PSAFn)]}{CFA}$$

**Where**

| | | |
|---|---|---|
| ACLL | = | adjusted connected lighting load |
| $W_T$ | = | total lighting watts in building |
| $CW_{1,2,\ldots,n}$ | = | watts of lighting in space 1,2,...,n with controls as specified in Table 10-3. |
| $PSAF_{1,2,\ldots,n}$ | = | power savings adjustment factor for space 1,2,...,n, as specified in Table 10-2 |
| CFA | = | conditioned floor area of the building |

**Table 10-1. WATTS PER SQUARE FOOT VALUES APPLICABLE TO OFFICES, RETAIL & WHOLESALE STORES**

| Illuminance Category** | Watt Per Square Foot RCR 0 to 3.5 | RCR 3.5+ to 7 | RCR 7+ | See Note |
|---|---|---|---|---|
| A(3) | .2 | .3 | .4 | -- |
| B(7.5) | .4 | .5 | .8 | -- |
| C(15) | .6 | .8 | 1.2 | -- |
| D(30) | 1.2 | 1.5 | 1.8 | -- |
| E(75) | 2.8 | 3.6 | 4.7 | 1 |
| F(150) | 5.0 | 6.0 | 10.1 | 1 |

| | Task Area < 2 ft² or Throw Distance* > 8 ft | Task Area ≥ 2 ft² | See Note |
|---|---|---|---|
| G(300) | 26 | 13 | 1 |
| H(750) | 63 | 33 | 1 |
| I(1,500) | 130 | 65 | 1 |

* "Throw Distance" is defined as distance, documented on plans, between luminaire and center of lighted plane on a feature display.

** Numbers in parentheses are the mid-range footcandle levels for the illuminance category.

NOTES TO TABLE 10-1:

1. Maximum connected lighting load for these tasks shall be based on a combination of general and task-oriented lighting. Lighting for these tasks or retail feature displays shall be obtained by local lighting, and shall be confined to the specific task area, which shall be described. For store feature displays, each feature display and identification of its lighting equipment shall be shown on plans. Any lighting power allotment determined for these tasks, that is more than the lighting power level actually installed, shall not be applied to other task areas.

TABLE 10-2

| Area or Task | Designate as Illuminance Category |
|---|---|
| Gross Sales Area [1] | D |
| Valance[2] | F |
| Feature Displays[3] | G |
| Show Windows | G |
| All Others | See Section 1001.2.1.3 |

FOOTNOTES TO TABLE 10-2:

1. Gross sales area equals the total of merchandise, display, sales transaction, fitting room and associated circulation and entry areas.

2. Valance lighting is defined, for the purpose of determining its power allotment, as a system of luminaries arranged to provide accent lighting power illumination along a wall surface. The valance lighting power allotment equals the task-oriented watts per square foot value shown for illuminance category F and RCR 0 to 3.5 multiplied by the area formed by multiplying a two foot wall surface width times the florescent luminaire length. This is equivalent to 10 watts per linear foot times the fluorescent luminaire length.

Detailed dimensioned documentation on plans must be shown when an allotment is taken for more than one tier of valance luminaries. To qualify as a separate tier, a minimum of 2 feet vertical separation between valances must exist. For valance lighting systems using other than fluorescent types of luminaries, the area used for the allotment shall be calculated as the length of accented wall times a two foot wall surface width.

3. Feature display is defined as an item or items requiring special highlighting to visually attract attention and set apart from the surrounding area. Such items in stores larger than 1,000 square foot are not a part of merchandise directly assessable to customers.

The lighting power allotment for feature display shall be:

a. The greater of 1000 watts or the wattage determined by multiplying the Table 10-1 watts per square foot value times 5 percent of the gross sales area; an

FOOTNOTES 10-2 CONTINUED

b. Where lighting is provided for wall mounted feature displays, a separate additional allotment equal to the wattage determined by multiplying the Table 10-1 watts per square foot value times 10 percent of the total wall area in the gross sales area, excluding fitting rooms. When valance lighting is installed, the wall display allotment calculation shall exclude an area equal to the valance length times six feet for the first tier and times two feet for subsequent tiers of valance.

TABLE 10-3 ADJUSTMENT FACTORS FOR SPECIAL LIGHTING CONTROLS[1]

| Control Type | Power Savings Adjustment Factor[2] | Applicable Building Spaces(s) |
|---|---|---|
| Occupant-Sensing Devices[3,5] | 0.30 | Any single space up to 250 square feet and enclosed by ceiling height partitions; classroom, conference rooms, computer rooms, storage areas, corridors or waiting rooms. |
| Daylighting Controls[4,5] | | Any daylit space[6] |
| Continuous Dimming | 0.30 | |
| Stepped Controls | 0.20 | |
| Programmable Timing Controls[7] | 0.15 | Any space |
| Lumen Maintenance Controls[5] | 0.10 | Any space |
| Daylighting Controls[4,5] with Occupant Sensing Devices | 0.44 | Any single space up 250 square feet within daylit spaces and enclosed by ceiling height partitions |
| Occupant Sensing Devices[3,5] with Lumen Maintenance Controls | 0.37 | Any single space up to 250 square feet and enclosed by ceiling height partitions |

FOOTNOTES TO TABLE 10-3:

1. Adjustment factor shall be allowed for controls required under provisions of Section 505.4. Dimming controls of incandescent lamps or luminaries shall not qualify.

2. Except as shown, only one adjustment factor may be used for each building space or luminaire, and 50% or more of the luminaire shall be within the applicable space to qualify for the power savings adjustment factor. These controls must be installed in series with the lights and in series with all manual switching devices in order to qualify for an adjustment factor.

3. To qualify for the power savings adjustment factor, occupant-sensing device shall meet the criteria to Section 505.4.1.2. Separate sensors and switching must be provided for each enclosed space or area.

4. Daylighting controls shall be able to reduce electric power consumption for the controlled lighting to 50 percent or less of maximum power consumption, shall control all luminaries delivering more than 50 percent of its light output to surfaces outside daylit spaces.

5. Lighting controls shall meet the requirements of Section 505.4.

6. The daylit space must be illuminated by either:

   A. Glazing in walls more than 3 feet in vertical extent with its highest edge 4 or more feet above the floor of the daylit area; or

   B. Glazing in roofs with sash, 2 square feet or more in area.

7. Programmable timing controls used for credit in conjunction with Table 10-2 must be capable of:

   A. Programming different schedules for weekdays and weekends; and

   B. Temporary overrides by occupant with automatic return to the original schedules. Override controls shall be readily accessible; and

   C. Providing independent control of each lighting load which is required to be separately controlled Section 505.4.1.2 does not apply and provisions of Section 505.4.1.5 must be met.

# NORTHWEST ENERGY CODE

**(UBC COMPATIBLE CODE)**

**JUNE 1987**

Amendments to the MODEL ENERGY
CODE to be equivalent to the
Model Conservation Standards

## FOREWORD

The development of this "Northwest Energy Code" which are amendments to the Model Energy Code, 1986 edition, was sponsored by the Bonneville Power Administration (BPA). Information on this document may be obtained from BPA, PO Box 3621, Portland, OR 97208.

This document contains deletions to the Council of American Building Officials' (CABO) Model Energy Code (MEC), 1986 Edition as well as additional requirements. A copy of the MEC can be obtained from CABO at 1201 One Skyline Place, 5205 Leesburg Pike, Falls Church, Virginia 22041, telephone (703)931-4533; International Conference of Building Officials (ICBO) 5360 South Workman Mill Road, Whittier, CA 90601; or Northwest Regional Office ICBO, 12505 Bellevue-Redmond, Suite 208, Bellevue, WA 98005, telephone (206)451-9541;

This code has been designed to be as compatible as possible with state and local regulations and is intended to be for those who want a document designed as a complete energy code chapter in t he Uniform Building Code. A related document has been prepared by BPA and is available from the Northwest ICBO Regional Office.

## DISCLAIMER

The Bonneville Power Administration acknowledges that although these amendments are based on The Model Energy Code, 1986 edition, published and copyrighted by CABO, the technical requirements contained therein **ARE NOT THE SAME AS THE MODEL ENERGY CODE** and are **NOT** based on a national consensus.

The provisions of this code do not consider the efficiency of various energy forms as they are delivered to the building envelope, i.e., delivered energy efficiency. The appropriate factor for delivered energy--efficiency should be considered prior to the selection of the mechanical, electrical, illumination systems, and energy form for specific uses. A determination of delivered energy efficiencies when used in conjunction with this code will provide the most efficient use of available energy in new building construction.

## TABLE OF CONTENTS

**CHAPTER 53. ENERGY CONSERVATION REQUIREMENTS**

SEC 5301 **General Requirements**.................... 1
5301(a) Intent.................................. 1
5301(b) Scope................................... 1
5301(c) Material and Equipment.................. 2
5301(d) Plans and Specifications................ 2
5301(e) Definitions............................. 2

SEC 5302 **Material Standards**...................... 12

SEC 5303 **Design Conditions**....................... 15
5303(a) Design Criteria......................... 15
5303(b) Thermal Design Parameters............... 15
5303(c) Mechanical Ventilation Criteria......... 16

SEC 5304 Building Design by Systems Analysis...... 22
5304(a) Scope................................... 22
5304(b) Systems Analysis........................ 22

SEC 5305 **Building Design by Component Performance Approach**......................................... 26
5305(a) Scope................................... 26
5305(b) Building Envelope Requirements.......... 26
5305(c) Building Mechanical Systems............. 34
5305(d) Service Water Heating................... 42
5305(e) Electrical Power and Lighting........... 43

SEC 5306 **Building Design by Prescriptive Requirements**.................................... 56
5306(a) Scope................................... 56
5306(b) Building Envelope Requirements.......... 56
5306(c) Air Leakage............................. 58
5306(d) Building Mechanical Systems............. 58

SEC 5307 **Building Design by Component Point System**.......................................... 64
5307(a) Scope................................... 64
5307(b) Calculation Procedure................... 64

**Chapter 60 Standards**............................... 71
NWEC Std #25. Ventilation System Installation... 73
NWEC Std #26. Air-to-Air Heat Exchangers........ 94

**APPENDIX**...................................... 99
SEC 5310 **Optional Calculation for Connected Loads** 101

TABLE OF CONTENTS


SEC 5309 **Radon Mitigation, Specifications**................ 1

5309(a) Scope & Definition..................... 1

5309(b) General Requirements................... 1

5309(c) Monitoring for Radon Gas................ 1

5309(d) Radon Mitigation for Buildings with Basements.............................. 2

5309(e) Radon Mitigation for Buildings With Slab Grade Systems.......................... 3

5309(f) Radon Mitigation for Buildings With Crawlspace Systems..................... 4

# CHAPTER 53
# ENERGY CONSERVATION REQUIREMENTS

## General Requirements

**Sec. 5301. (a) Intent.** The provisions of this chapter shall regulate the design of building envelopes for adequate thermal resistance and low air leakage and the design and selection of mechanical, electrical, service water heating and illumination systems and equipment which will enable effective use of electric energy in building construction.

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

1. A systems approach for the entire building and its energy-using subsystems,section 5304;
2. A component performance approach for various building elements and mechanical systems and components, section 5305; or
3. A prescriptive requirements approach, section 5306; or
4. A component point system approach, section 5307.

Subject to the limits which apply to each section, compliance with any one of these paths meets the intent of this code.

(b) **Scope.** This section sets forth minimum requirements for the design of new buildings and structures or portions thereof and additions, alterations and repair to existing buildings that provide facilities or shelter for public assembly, educational, business, mercantile, institutional, storage and residential occupancies, as well as those portions of factory and industrial occupancies, designed primarily for human occupancy by regulating their exterior envelopes and the selection of their HVAC, service water heating, electrical distribution and illuminating systems and equipment for effective use of electric energy.

**EXCEPTIONS:** Buildings and structures or portions thereof meeting any of the following criteria shall be exempt from the building envelope requirements of Sections 5305 (b), 5306(b) and 5307(b). However, the energy uses from all sources shall be included in any analysis performed pursuant to section 5304:

1. Buildings and structures or portions thereof whose peak design rate of energy usage is less than 3.4 Btu/h per square foot or 1.0 watt per square foot of floor area for space conditioning requirements.
2. Buildings and structures or portions thereof which are neither heated or cooled according to the definitions in section 5301(e), provided that any space heating equipment which is installed complies with all of the following criteria:

(a) Sized for a maximum interior design temperature of less than 50 degrees F.
(b) Equipped with thermostatic control which is manufactured to have a maximum temperature setting of 50°F or less.

Those parts of lighting systems which are altered or replaced in buildings initially constructed to the requirements of this code shall comply with Section 5305 (e) 4. In addition, other remodels or replacements which affect the lighting system of a floor shall also comply with the lighting power budgets specified in Section 5305 (e) 3.

(c) **Materials and Equipment.** 1. **Identification.** Materials and equipment shall be identified in order to show compliance with this code.

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

(d) **Plans and Specifications.** 1. **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 to be prepared by an engineer or architect licensed to practice by the state. (Designs submitted under the provisions of section 5304 for other than low rise R-3 occupancies shall be prepared by an engineer or architect licensed to practice by the state.)

2. **Details.** The plans and specifications shall show in sufficient detail 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.

(e) **Definitions.** For the purposes of this chapter, certain abbreviations, terms, phrases, words and their derivatives, shall be as follows:

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

**ACCESSIBLE** (as applied to equipment). Admitting close approach because not guarded by locked doors, elevation or other effective means. (See **READILY ACCESSIBLE.**)

**ADVANCED FRAMING.** Framing techniques used to minimize the amount of uninsulated material that is not required for proper structural support.

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

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

**AUTOMATIC.** Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature or mechanical configuration. (See **MANUAL.**)

**BELOW GRADE WALLS.** Walls or the portion of walls which extend two feet or more below the finish grade.

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

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

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

**CLERESTORY.** A window placed in a wall projecting from a roof plane at sixty (60) degrees or more from the horizontal to admit daylight into the interior of a building. (See **Skylight.**)

**COEFFICIENT OF PERFORMANCE (COP).** See the following paragraphs in Chapter 5 for the definitions of COP as appropriate:

| | |
|---|---|
| Electrically Operated HVAC System Equipment--Cooling | 5305 (c) 4D(ii) |
| Applied HVAC System Components--Cooling | 5305 (c) 4E(i) |
| Heat Pump--Heating | 5305 (c) 4B(ii) |

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

**CONDITIONED FLOOR AREA.** The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

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

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

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

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

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

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

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

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

**ENERGY, RECOVERED.** (See **RECOVERED ENERGY.**)

**EXTERIOR ENVELOPE.** (See **BUILDING ENVELOPE.**) Floor over unconditioned space (enclosed). Floor over unconditioned space (exposed).

**FLOOR OVER UNCONDITIONED SPACE (ENCLOSED).** A floor which separates a conditioned space from an unconditioned space which is buffered from exterior ambient conditions including vented crawlspaces and unconditioned basements or other similar spaces.

**FLOOR OVER UNCONDITIONED SPACE (EXPOSED).** A floor which separates a conditioned space from an unconditioned space exposed to exterior ambient conditions including open parking garages and enclosed garages which are mechanically ventilated.

**F-VALUE.** The perimeter heat loss factor expressed in Btu/h-F

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

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

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

**GROSS EXTERIOR WALL AREA.** The normal projection of the building envelope wall area bounding interior space which is conditioned by an energy-using system; includes opaque wall, window and door areas.

The gross area of walls consists of all opaque wall areas, including foundation walls, between floor spandrels, peripheral edges of floors, window areas including sash, and door areas, where such surfaces are exposed to exterior ambient conditions and enclose a conditioned space including interstitial areas between two such spaces.

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

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

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

**HEATED SPACE.** Space within a building which is provided with a positive heat supply to maintain a temperature of greater than 50°F. Finished living space within a basement or registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space.

**HEATING SEASON PERFORMANCE FACTOR (HSPF).** The total heating output (in Btu) of a heat pump during its normal annual usage period for heating divided by the total (watt hour) electric power input during the same period, as determined by test procedures consistent with the U.S. Department of Energy "Test Procedure for Central Air Conditioners, Including Heat Pumps" published in the December 27, 1979, Federal Register, Vol 44, No. 24, IOCFR. 430. When specified in Btu per watt hour an HSPF of 6.826 is equivalent to an HSPF of 2.0 watt hour per watt hour.

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

**HVAC.** Heating, ventilating and air conditioning.

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

**HVAC SYSTEM EFFICIENCY.** (See **EFFICIENCY, HVAC SYSTEM.**)

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

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

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

**LOW-RISE BUILDING.** A building not exceeding three stories in height.

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

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

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

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

**OPERABLE WINDOW INSULATION.** Movable window covers of insulating material which have means to create an edge fit better than a loose fit (i.e., interlocking edge, cushion seal, mechanical, or magnetic seal) and with a minimum thermal resistance of R-5.

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

**PACKAGED TERMINAL AIR CONDITIONER.** A factory-selected combination of heating and cooling components, assemblies or sections intended to serve a room or zone. (For the complete technical definition, see Standard RS-10.)

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

**PERMEANCE** (perm). The ability of a material of specified thickness to transmit moisture in terms of amount of moisture transmitted per unit time for a specified area and differential pressure (grains per hour-ft$^2$-in.HG). Permeance may be measured using ASTM E-96-72 or other approved dry cup method as specified in RS-1.

**POSITIVE COOLING SUPPLY.** Mechanical cooling deliberately supplied to a space, such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space-cooling components, such as evaporator coil cases and cooling distribution systems which continually maintain air temperatures within the space of 85 degrees F or lower during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

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

**POSITIVE COOLING SUPPLY.** Mechanical cooling deliberately supplied to a space, such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space cooling components, such as evaporator coil cases and cooling distribution systems which continually maintain air temperatures within the space of 85 degrees F, or lower during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

**POSITIVE HEAT SUPPLY.** Heat deliberately supplied to a space by design, such as a supply register, radiator or heating element. Also, heat indirectly supplied to a space through uninsulated surfaces of service water heaters and space heating components, such as furnaces, boilers and heating and cooling distributions systems which continually maintain air temperature within the space of 50 degrees F or higher during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

**POWER.** The rate at which electric energy is transmitted; in customary units, measured in watts (W) or British thermal units per hour (Btu/h).

**POWER FACTOR.** The ratio of the true power (watts) to the apparent power (volts times amperes), the cosine of the angle of lag between the alternating current and the voltage waves.

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

**R-VALUE.** Thermal resistance as measured in degrees F-ft$^2$-hr/Btu. Nominal R-Value shall mean thermal resistance of insulation (excluding structural or sheathing components) as specified by the manufacturer according to recognized trade and engineering standards or approved equal.

**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.**)

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

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

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

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

**ROOF/CEILING ASSEMBLY.** A roof/ceiling assembly shall be considered as all components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed exterior ambient conditions to and encloses a conditioned space.

The gross area of a roof/ceiling assembly consists of the total interior surface of such assembly, including skylights.

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

**SEQUENCE.** A consecutive series of operations.

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

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

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

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

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

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

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

**STANDARD FRAMING.** All framing practices not defined as "advanced" shall be considered standard.

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

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

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

**THERMAL CONDUCTANCE (C).** The thermal transmission in unit time through unit area of a particular body or assembly having defined surfaces when the unit average temperature is established between surfaces (Btu/hr ft$^2$ F).

**THERMAL RESISTANCE (R).** The reciprocal of thermal conductance (hr ft$^2$ F/Btu).

**THERMAL TRANSMITTANCE (U).** The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/hr-ft$_2$ °F). The U- value applies to fractional combinations of different materials used in series along the heat flow path.

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

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

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

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

**VAPOR RETARDER.** A layer of low moisture transmissivity material (not more than 1.0 perm dry cup) placed over the warm side (in winter) of insulation, over the exterior of below grade walls, and under floors as ground cover to limit the transport of water and water vapor through exterior walls, ceilings, and floors.

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

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

**VENTILATION AIR.** That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. (See Table 53-A, Section 5303 of this code, and definition of **OUTDOOR AIR.**)

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

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

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

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

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

**Material Standards**

**Sec. 5302.** The standards and portions thereof, which are referred to in various parts of this chapter are hereby declared to be a part of this code.

| CODE STANDARD NO. | TITLE AND SOURCE |
|---|---|
| RS-1 | 1985 ASHRAE Handbook of Fundamentals |
| RS-2A | Standard Method of Test for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors, Specification E283-73 of ASTM.<br><br>Specifications for Aluminum Windows, ANSI A134.1, 1972 Specifications for Aluminum Sliding Glass Doors, ANSI A134.2, 1972.<br><br>Industry Standard for Wood Window Units, NWMA IS-2,Industry Standard for Wood Sliding Patio Doors, NWMA IS-3. |
| RS-2B | AAMA 1503.1, 1980 Voluntary Test Method for Thermal transmittance of windows, doors and glazed wall sections. |
| RS-2C | ASTM C236 test for thermal conductance and transmittance of built-up sections by means of a guarded hot box; and ASTM C976 thermal performance of building assemblies by means of the calibrated hot box. |
| RS-3 | ASHRAE Standard 62-81 Ventilation for acceptable indoor air quality. |
| RS-4 | ASHRAE Standard 55-74 Thermal Environmental Conditions for Human Occupancy. |
| RS-5 | DOE Test Procedures for Water Heaters, 10 CFR Part 430 Appendix E to Subpart B. |
| R6 | Household Automatic Electric Storage-Type Water Heaters, ANSI C72.1-1972. |
| R7 | Gas Water Heaters, Volume III, Circulating Tank, Instantaneous and Large Automatic Storage-Type Water Heaters, ANSI Z21.10.3, 1974. |

RS-8 IES Lighting Handbook, 6th Edition, 1981 Illuminating engineering Society.

RS-9 ASHRAE Standard 90A-1980, Energy Conservation in New Building Design.

RS-10 Standard for Packaged Terminal Air Conditioners, ARI Standard 310-70.

RS-11 1984 ASHRAE Systems Handbook.

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

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

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

RS-15 1983 ASHRAE Equipment Handbook.

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

RS-17 SMACNA Low Pressure Duct Construction Standards, 5th Edition, Washington, D.C., 1976.

RS-18 SMACNA High Pressure Duct Construction Standards, 3rd Edition, Washington, D.C., 1975.

RS-19 SMACNA Fibrous Glass Duct Construction Standards, 5th Edition, Washington, D.C., 1979.

RS-20 1982 ASHRAE Handbook and Product Directory, Applications Volume.

RS-21 Standard for Package Terminal Heat Pumps, ARI Standard 380-78.

RS-22 ASTM E779-781 Standard practice for measuring air leakage by the fan pressurization method.

RS-23 ASTM E741 Standard practice for measuring air leakage by the tracer dilution method.

RS-24 Standard 24 CFR Part 3280 HUD.

| | |
|---|---|
| NWEC Std No. 25 | Ventilation System Installation Standards |
| NWEC Std No. 26 | Bonneville Power Administration Air-to-Air Heat Exchangers Product Specifications |

## ACCREDITED AUTHORITATIVE AGENCIES

AAMA refers to the American Architectural Manufacturers Association, 35 East Wacker Dr., Chicago, ILL, 60601

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

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

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

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

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

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

NWMA refers to the National Woodwork Manufacturers Association, Inc., 400 Madison Ave., Chicago, IL 60606

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

**Design Conditions**

**Sec. 5303.** (a) **Design Criteria.** 1. General. The criteria of this chapter establish the design conditions upon which the minimum thermal design requirements of the building envelope and the design of the HVAC system are to be based.

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

The design shall not create conditions of accelerated deterioration from moisture condensation.

(b) **Thermal Design Parameters.** 1. Exterior Design Conditions. The following design parameters shall be used for calculations required under this chapter. (The Building Official is to fill in with applicable data.)

| EXTERIOR DESIGN CONDITIONS | | |
|---|---|---|
| WINTER[1] | Design Dry-bulb | °F |
| SUMMER[1] | Design Dry-bulb | °F |
| | Design Wet-bulb | °F |
| DEGREE DAYS HEATING | | |
| DEGREES NORTH LATITUDE | | |

The outdoor design temperature shall be selected from the columns of 97-1/2 % values for winter (99% values for Zone 3) and 2-1/2 % values for summer from tables in Standard RS-1. Adjustments may be made to reflect local climates as determined by the building official.

2. **Interior Design Conditions.** A. **Indoor Design Temperature.** Indoor design temperature shall be 70 degrees F for heating and 78 degrees F for cooling.

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

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

C. **New Energy for Humidity Control.** New energy may be used to prevent relative humidity from rising above 60 percent for comfort control, to prevent condensation on terminal units or outlets, or to prevent the malfunctioning of special equipment.

D. **Heating and Cooling Degree Days.** The heating and cooling degree days shall be selected from the Standard RS-1. For locations not listed therein, other sources of heating and cooling degree data may be used provided such sources are approved by the Building Official.

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

Zone 1. Less than 6,000 degree days at 65 degrees F Base.
Zone 2. 6,000 to 8,000 degree days at 65 degrees F Base.
Zone 3. More than 8,000 degree days at 65 degrees F Base.

(c) **Mechanical Ventilation Criteria.** 1. **Ventilation.** For minimum ventilation requirements see the applicable occupancy chapters. See also section 5305 (b) 1H.

If a mechanical ventilation system is provided in lieu of natural ventilation, the mechanical ventilation system shall be capable of supplying to each zone ventilation air with the minimum outdoor air quantities specified in Table No. 53-A based upon the greater of the occupant densities in that table or the design occupant density. The outdoor air shall be conveyed by ducts to each zone not provided with minimum openable area for natural ventilation. The maximum outdoor air quantities used as the basis for calculating the heating and cooling design loads shall not exceed three times the quantities specified in Table No. 53-A. See the Uniform Mechanical Code for other requirements.

**EXCEPTIONS:** 1. If outdoor air quantities other than those specified in Table No. 53-A are used or required because of special occupancy or process requirements, source control of air contamination, health and safety or other standards, the required outdoor air quantities shall be used as the basis for calculating the heating and cooling design loads.

2. Except as limited in this Section, recirculated air may be used to meet part of the outdoor air requirements provided that an air cleaning system is installed which is designed to remove particulate and gaseous contaminants and which otherwise complies with Section 6.1.4 of Standard RS-3. A minimum of 5 cfm of outdoor air per person shall be provided.

TABLE NO. 53-A
OUTDOOR AIR REQUIREMENTS FOR VENTILATION[1]

| | Estimated Occupancy[2] persons per 1000 sq ft[2] | Outdoor Air Requirements cfm/person (except as noted) |
|---|---|---|
| Dry Cleaners and Laundries | | |
| Commercial | 10 | 15 |
| Storage/pick-up areas | 30 | 35 |
| Coin-operated laundries[3] | 20 | 35 |
| Coin-operated dry cleaning | 20 | 15 |
| Food & Beverage Services | | |
| Dining rooms | 70 | 35 |
| Kitchens | 20 | 10 |
| Cafeterias, fast food facilities | 100 | 35 |
| Bars and cocktail lounges | 100 | 50 |
| Garages, Auto Repair Shops, Service Stations | | |
| Parking garages (enclosed)[4] | (cfm/sq ft) | 1.5 |
| Auto Repair workrooms (general)[4] | " | 1.5 |
| Hotels, Motels, Resorts, Dormitories & Correctional Facilities[5] | | |
| Bedrooms (single, double)[6] | (cfm/room) | 30 |
| Living rooms (suites)[6] | " | 50 |
| Baths, toilets (attached to bedrooms)[7] | " | 50 |
| Lobbies | 30 | 15 |
| Conference rooms (small) | 50 | 35 |
| Assembly rooms (large) | 120 | 35 |
| Gambling casinos | 120 | 35 |
| Offices | | |
| Office space | 7 | 20 |
| Meeting and waiting spaces | 60 | 35 |

TABLE NO. 53-A Continued

| | Estimated Occupancy[a] persons per 1000 sq ft[a] | Outdoor Air Requirements cfm/person (except as noted) |
|---|---|---|
| **Public Spaces** | | |
| Corridors and utility rooms | (cfm/sq ft) | .02 |
| Public restrooms | (cfm/stall/urinal) | 75 |
| Locker & dressing rooms | (cfm/locker) | 35 |
| **Retail Stores** | | |
| Sales floors & showrooms | | |
| Basement & street floors | 30 | 25 |
| Upper floors | 20 | 25 |
| Storage areas (serving sales and storerooms) | 15 | 25 |
| Dressing rooms | -- | 25 |
| Malls and arcades | 20 | 10 |
| Shipping & receiving areas | 10 | 10 |
| Warehouses | 5 | 10 |
| Elevators | -- | 15 |
| Smoking rooms | 70 | 50 |
| **Specialty Shops** | | |
| Barber & beauty shops | 25 | 35 |
| Reducing salons, health spas (exercise rooms) | 20 | |
| Florists[a] | 10 | 25 |
| Greenhouses | 1 | |
| Show repair shops (combined workrooms/trade areas) | 10 | 15 |
| Pet shops | | 1 |
| **Sports and Amusement Facilities** | | |
| Ballrooms and discos | 100 | 35 |
| Bowling alleys (seating area) | 70 | 35 |
| Playing floors (e.g. gymnasiums, ice arenas)[7] | 30 | 20 |
| Spectator areas | 150 | 35 |
| Game rooms (e.g. cards & billiards rooms) | 70 | 35 |

TABLE NO. 53-A Continued

| | Estimated Occupancy[a] persons per 1000 sq ft[2] | Outdoor Air Requirements cfm/person (except as noted) |
|---|---|---|
| Sports and Amusement Facilities (continued) | | |
| Swimming pools | | |
| Pool and deck areas[10] | (cfm/sq ft) | .5 |
| Spectators' area | 70 | 35 |
| Theatres | | |
| Ticket booths | | 20 |
| Lobbies, foyers, lounges & auditoriums in motion picture theatres, lecture, concert & opera halls | 150 | 35 |
| Stages, TV and movies studios[11] | 70 | 10 |
| Transportation | | |
| Waiting rooms, ticket & baggage areas, corridors & gate areas, platforms, concourses[12] | 150 | 35 |
| Workrooms | | |
| Meat processing rooms[13] | 10 | 5 |
| Pharmacists' workroom | 20 | 7 |
| Bank vaults | 10 | 5 |
| Photo studios | | |
| Camera room, stages | 10 | 5 |
| Darkrooms | 10 | 20 |
| Duplicating & printing rooms[14] | (cfm/sq ft) | 0.5 |
| Educational Facilities | | |
| Classrooms | 50 | 25 |
| Laboratories[15] | 30 | 10 |
| Training shops | 30 | 35 |
| Music rooms | 50 | 35 |
| Libraries | 20 | 5 |

TABLE NO. 53-A Continued

| | Estimated Occupancy[2] persons per 1000 sq ft[2] | Outdoor Air Requirements cfm/person (except as noted) |
|---|---|---|
| Hospital, Nursing & Convalescent Homes[16] | | |
| Patient rooms | (cfm/bed) | 35 |
| Medical procedure areas[17] | 10 | 35 |
| Operating rooms, delivery rooms | 20 | 40 |
| Recovery & intensive care rooms | 20 | 15 |
| Autopsy rooms[18] | 20 | 100 |
| Physical therapy areas | 20 | 15 |
| Residential[19] | | |

**Footnotes to Table 53-A**

1. Derived from Standard RS-3.

2. Use only when design occupancy is not known.

3. Dry cleaning processes may require more air.

4. Distribution must consider worker location and concentration of running engines, stands where engines are run must incorporate systems for positive engine exhaust withdrawal.

5. See also food and beverage services, merchandising, barber and beauty shops, and garages.

6. Independent of room size.

7. Independent of room size, installed capacity for intermittent use.

8. Ventilation to optimize plant growth may dictate requirements.

9. When internal combustion engines are operated for maintenance of playing surfaces, increased ventilation rates will be required.

## Footnotes Continued

10. Higher values may be required for humidity control.

11. Special ventilation will be needed to eliminate special stage effects (e.g., dry ice vapors, mists, etc.)

12. Ventilation within vehicles will require special consideration.

13. Spaces maintained at low temperatures (-10°F to +50°F) are not covered by these requirements unless the vacancy is continuous. Ventilation from adjoining space is permissible. When the occupancy is intermittent, infiltration will normally exceed the ventilation requirement.

14. Installed equipment must incorporate positive exhaust and control (as required) of undesirable contaminants (toxic or otherwise).

15. Special contaminant control systems may be required for processes or functions including laboratory animal occupancy.

16. Special requirements or codes and pressure relationships may determine minimum ventilation rates and filter efficiency.

17. Procedures generating contaminants may require higher rates.

18. Air shall not be recirculated into other spaces.

19. See section 5304(b)1H.

**Building Design by Systems Analysis**

**Sec. 5304.** (a) **Scope.** This section establishes design criteria in terms of total energy use by a building, including all of its systems. Analysis of design for low rise R-1 and R-3 occupancies and other buildings less than 5000 sq ft shall comply with Section 530. Analysis of design for other buildings shall comply with Sections 5304 to 5304.

(b) **Systems Analysis.** 1. Energy Analysis For All Buildings Except Low rise R-1 and R-3 occupancies and other buildings less than 5000 sq ft.

Compliance with this section will require an analysis of the annual electric energy usage, hereinafter called an annual energy analysis.

> **EXCEPTION:** Sections 5405, 5406, and 5407 of this code establish criteria for different energy-consuming and enclosure elements of the building which, will eliminate the requirement for an annual energy analysis while meeting the intent of this code.

A building designed in accordance with this section will be deemed as complying with this code if the calculated annual energy consumption is not greater than a similar building (defined as a "standard design") whose enclosure elements and energy-consuming systems are designed in accordance with section 5305.

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

2. **Design.** The standard design, conforming to the criteria of section 5305 and the proposed alternative design shall be designed on a common basis as specified herein:

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

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

A. The building heating/cooling load calculation procedure used for annual energy consumption analysis shall be detailed to permit the evaluation of effect of factors specified in Section 402.4.

B. The calculation procedure used to simulate the operation of the building and its service systems through a full-year operating period shall be detailed to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data shall be used when available in the simulation of systems and equipment. The calculation procedure shall be based upon 8760 hours of operation of the building and its service systems and shall utilize the design methods specified in Standards RS-1, -11, -12 and -13.

4. **Calculation Procedure.** The calculation procedure shall cover the following items:

A. Design requirements--Environmental requirements as required in section 5303.

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

C. Building data--Orientation, size, shape, mass, air, moisture and heat transfer characteristics.

D. Operational characteristics--temperature, humidity, ventilation, illumination, control mode for occupied and unoccupied hours.

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

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

5. **Documentation.** Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis comparison report. The report shall provide technical detail on the two building and system designs and on the data used in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of section 5304.

6. **Energy Analysis for Low rise R-1 and R-3 Occupancies and other buildings less than 5000 sq.ft. A. Energy Budgets.** Proposed buildings designed in accordance with this section shall be designed to use no more kilowatt hours (kWh) of electric energy from depletable sources for space heating than a similar building whose enclosure elements and energy consuming systems are designed in accordance with Section 5305 (b) 2 for the appropriate climate zone and building type. New buildings shall also meet the applicable requirements of Sections 5305 (b)4, 5305 (c)8 and 5305 (d).

B. **Calculation of Energy Consumption.** The application for a building permit shall include documentation which demonstrates, using an approved calculation procedure, that the proposed building's space heating energy use does not exceed the space heating energy use of a similar building conforming to section 5305 for the appropriate climate zone. The total calculated annual electricity consumption shall be shown in units of kWh/sq ft or Btu/sq ft of conditioned area.

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

| Parameter | Value |
|---|---|
| Thermostat set point, heating | 65 degrees F |
| Thermostat set point, cooling | 78 degrees F |
| Thermostat night set back | 0 degrees F |
| Thermostat night set back period | 0 hours |
| Internal gain from lights, appliances and occupants | 3000 Btu/hr (for R-3 occupancies) 1500 Btu/hr (R-1 occupancies) |
| Minimum heat storage | Calculated using standard engineering practice for the actual building or as approved. |
| Site weather data | Typical meteorological year (TMY) or ersatz TMY data for the closest appropriate TMY site or other sites as approved. |
| Heating system efficiency | Systems providing electric resistance heat other than heat pumps are assumed to have an efficiency of 1.00. |

Parameter values that may be varied by the building designer to model energy saving options include, but are not limited to, the following:

1. Overall thermal transmittance, $U_o$, of building envelope or individual building components.
2. Heat storage capacity of building;
3. Glazing orientation and area; and,
4. Heating system efficiency.

D. **Solar Shading and Access.** Building designs using passive solar features with 8 percent or more south facing equivalent glass to qualify shall provide to the Building Official a sun chart or other approved documentation depicting actual site shading for use in calculating compliance under this section. Building designs shall also document future solar access by indicating on the site plan that the solar aperture will not be shaded by a hypothetical six foot fence built on adjacent lot lines or by a hypothetical "pole" located at the center of the buildable area of adjacent lots that represents the average height of similar structures in the area.

E. **Infiltration.** Infiltration levels used shall be consistent with the air leakage control package selected from Section 5305 (b)4 or the designer shall provide documentation for alternative assumptions.

F. **Heat Pumps.** The heating season performance factor (HSPF) for heat pumps shall be calculated using procedures consistent with Section 5.2 of the U.S. Department of Energy Test Procedure for Central Air Conditioners, including heat pumps published in the December 27, 1979 Federal Register Vol. 44, No. 24.10 CFR 430. Climate data as specified above, the proposed buildings overall thermal performance value (Btu/degrees F) and the standardized input assumptions specified above shall be used to model the heat pumps HSPF.

**Building Design By Component Performance Approach**

**Sec. 5305. (a) Scope.** The criteria of this section establishes the minimum requirements for the thermal design of the exterior envelope of buildings which use electrical energy as the primary form of space conditioning, and for other electric energy using components associated with the building operation.

(b) **Building Envelope Requirements.** 1. **General.** A. The stated Uo value of any assembly such as roof/ceiling, wall or floor may be increased and the Uo value for other components decreased, provided that the total heat gain or loss for the entire building envelope does not exceed the total resulting from conformance to the Uo values specified in this section. Component heat loss or cooling coefficients shall be computed in accordance with the provisions of Chapter 23 and 25 of RS-1 and the requirements of this section.

B. In addition to the criteria set forth in this section, the proposed design may take into consideration the thermal mass of building components in considering energy conservation when approved by the building official.

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

(i) For thermal transmittance purposed, not include the ceiling proper nor the plenum space as part of the assembly; and

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

D. **Insulation.**

(i) All insulating materials shall comply with sections 1712 and/or 1713 of this Code. All insulation materials shall be placed in the building envelope in such a manner as to provide for uniform R-Value.

(ii) Where required, insulation shall be installed with clearances maintained through installation of a permanent retainer.

(iii) Access doors from conditioned spaces to unconditioned spaces (e.g., attics and crawl spaces) shall be weatherstripped and insulated to a level equivalent to the insulation on the surrounding surfaces. Access shall be provided to all equipment which prevents damaging or compressing the insulation.

(iv) Blown or poured loose-fill insulation may be used in attic spaces where the slope of the roof is not less than 2-1/2 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 joists 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 prior to the framing inspection. Baffles shall be of weather-resistant, rigid material.

(v) Insulation installed in exterior walls shall comply with the provisions of this section. All wall insulation batts shall fill the entire cavity and shall not be compressed. Exterior wall cavities isolated during framing shall be fully insulated to the levels of the surrounding walls.

(vi) Slab-on-grade 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 distance of 24 inches. Insulation installed outside the foundation shall extend downward to a maximum of 24 inches or to the frostline. Above grade insulation shall be protected.

**EXCEPTION:** For monolithic slabs, the insulation shall extend downward from the top of the slab to the bottom of the footing.

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

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

E. **Glazing.** For low rise R-1 and R-3 occupancies and other buildings less than 5000 sq ft, compliance with the U-Values for glazing shall be certified using thermal transmittance due to conduction test results from either RS-2B or RS-2C test procedures. Testing shall be conducted by a certified laboratory at a wind speed of 15 mph and using the residential sample size specified in RS-2B.

For the purpose of calculations the tested U-value may be adjusted to reflect a seasonal average condition of 7.5 mph using the procedure specified in Chapter 27 of RS-1.

**EXCEPTION:** U-Values for site- built fixed lites shall use window thermal test results when available.

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

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

(ii) Walls, ceilings, and floors separating conditioned space from unconditioned space shall have a vapor retarder installed. The vapor retarder shall have a one perm dry cup rating or less.

(iii) Slab-on-grade floors shall have a ground cover with a one-perm dry cup rating and approved for under slab use installed beneath the entire slab.

**EXCEPTION:** Slabs installed on a 2" minimum gravel base.

(iv) A dark ground cover of 6 mil (0.006 inch) thick polyethylene or approved equal shall be laid over the ground within crawl spaces. The ground cover shall be overlapped 12 inches minimum at joints and shall extend to the foundation wall.

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

G. **Indoor Air Quality for Low rise R-1 and R-3 Occupancies.**

(i) All structural panel components within the conditioned space shall comply with RS-24 for formaldehyde emissions of .2 PPM for plywood and .3 PPM for particle board and shall be so labeled.

**EXCEPTION:** Softwood plywood, particle board, wafer board and oriented strand board with phenol based resins and stamped EXPOSURE 1 or EXTERIOR.

(ii) Concrete slabs shall be a minimum 3-1/2" thick and shall be installed over a 4" thick coarse-grade gravel base.

(iii) Combustion appliances located within the conditioned space shall be either direct vent, forced draft or, other venting system taking combustion air directly from the exterior.

**EXCEPTIONS:** 1. Fireplaces and wood stoves shall comply with Section 5305 (b)4C(iii).
2. Cooking appliances.

H. **Mechanical Ventilation for low rise R-1 and R-3 occupancies.** The requirements of Table 53-A and Section 1205(a) notwithstanding, a ventilation system complying with NWEC Standard #25 and #26 shall be installed. The ventilation system shall be capable of providing the following ventilation requirements:

- **Spot Ventilation.** Intermittent operation exhaust ventilation of 50 cfm for each bathroom and 100 cfm for each kitchen.
- **Whole House Ventilation.** Outdoor air shall be supplied to the conditioned space at the rate of 10 cfm for each bedroom plus an additional 10 cfm for the remaining living area. The ventilation system shall be capable of providing the outdoor air on a continuous basis and shall be provided with an automatic control with a manual override.

2. Criteria For All Low rise Group R-1 and R-3 Occupancies and For Other Buildings Less Than 5000 sq.ft. The building envelope will be deemed as complying with this code if the calculated heat loss of the proposed building is not greater than the heat loss of a reference building complying with the requirements of Table No. 53-B. The building heat loss shall be calculated using Equation 53-1, 53-2, 53-3, 53-4 and 53-4.

The reference building shall have the same floor areas, gross exterior wall area, gross ceiling area and below grade wall or slab-on grade perimeters as the proposed building. The reference building shall use an air exchange rate of .35 ACH.

Component heat loss coefficients shall be calculated using the procedures in Chapters 23 and 25 of RS-1. The effects of all heat flow paths, including framing members and tapering or compression of the insulation shall be included. The buffering effects of adjacent unheated spaces may be considered. The seasonal average outdoor conditions may be used for determination of the outdoor air films.

$$U = \frac{1}{\frac{1}{f_o} + R_1 + R_2 + \ldots R_n + \frac{1}{f_i}} \quad \text{...(Equation 53-1)}$$

**WHERE:** U = the thermal transmittance of the assembly. (Btu/hr·sq.ft.·°F)
$f_o$ = outside air film conductance
$f_i$ = inside air film conductance
R = $\frac{1}{C}$ = measure of the resistance to the passage of heat for each element. (°F/Btu·sq.ft.·hr)
C = conductance, the heat flow through a specific material of specific thickness
General Equation for heat loss:

$$UA = U_i A_i \quad \text{or} \quad F_i P_i \text{.........(Equation 53-2)}$$

**WHERE:**
UA = component heat loss
$U_i$ = component U-Value
$A_i$ = component area (sq ft)
*$F_i$ = component F-factor
*$P_i$ = component perimeter (ft)
*(for slabs and below grade walls)

Effective Air Leakage Heat Loss Rate:

$$UA_i = ACH \times V \times C_p \times D \text{..............(Equation 53-3)}$$

**WHERE:**

$UA_i$ = heat loss from infiltration
*ACH= effective air exchange rate
$V$ = Volume of conditioned space
$C_p$ = specific heat capacity of air
$D$ = density of air at building location

* use .35 ACH for the Standard air leakage controls
.20 ACH for the Advanced air leakage controls

Building Total Heat Loss Rate:

$$UA_o = FP_b + FP_s + UA_f + UA_w + UA_g + UA_d + UA_c + UA_i \text{.....(Eq 53-4)}$$

**WHERE:**

$FP_b$ = UA for below grade walls
$FP_s$ = UA for slab on grade floors
$A_f$ = UA for floors over unconditioned spaces
$UA_w$ = UA for walls above grade
$UA_g$ = UA for glazing*
$UA_d$ = UA for doors
$UA_c$ = UA for ceilings
$UA_i$ = UA for air infiltration

All units in Btu/hr/degrees F
* - See Section 5301.(e) for definition of glazing.

3. **Criteria for All Other Buildings.** A. Heating Criteria. (i) **Walls.** The gross exterior wall shall have a combined thermal transmittance value ($U_o$) not exceeding the values given in Table No. 53-C. Equations 53-1 and 53-5 shall be used to determine acceptable combinations to meet this requirement. For below-grade-walls , the thermal resistance of the insulation shall not be less than the value given in Table No. 53-D.

General equation for gross wall area:

$$U_o = [U_w \times A_w + U_g \times A_g + U_d \times A_d]/A_o \text{...(Equation 53-5)}$$

**WHERE:**

Uw = average thermal transmittance of opaque wall.
Aw = opaque area of exterior walls above grade.
Ug = the thermal transmittance of the glazing.
Ag = the glazing area, including sash.
Ud = the thermal transmittance of the door.
Ad = the door area.
Uo = the average thermal transmittance of the gross wall area
Ao = the gross wall area

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

(Uw1 x Aw1) + (Uw2 x Aw2), + ... etc.

Calculations shall include the effects of all heat flow paths, including framing members.

(ii) **Roof/Ceiling.** The gross roof/ceiling shall have a combined thermal transmittance value (Uo) not exceeding the value given in Table No. 53-C. Equations 53-1 and 53-6 shall be used to determine acceptable combinations to meet this requirement.

General equation for gross roof/ceiling area:

$$U_o = [U_r \times A_r + U_s \times A_s]/A_o \text{.............(Equation 53-6)}$$

**WHERE:** Ur = the thermal transmittance of opaque roof/ceiling.
Ar = opaque roof/ceiling area.
Us = the thermal transmittance of skylight.
As = skylight area (including frame).
Uo = the average thermal transmittance of the gross roof/ceiling
Ao = the gross roof/ceiling area

Note: Where more than one type of roof/ceiling and/or skylight is used, the U x A term for that exposure shall be expanded into its sub-elements, as:

(Ur1 x Ar1) + (Ur2 x Ar2), + ... etc.

Calculations shall include the effects of all heat flow paths, including framing members.

(iii) For floors of heated spaces over unheated spaces, the Uo value shall not exceed the value given in Table No. 53-C.

(iv) **Slab-on-grade floors.** For heated and unheated slab-on-grade floors, the thermal resistance of the insulation around the perimeter of the floor shall be not less than the value given in Table No. 53-C.

4. **Air Leakage for All Buildings.** A. **General.** The requirements of this section shall apply to all buildings and structures, or portions thereof, and apply to those locations separating exterior ambient conditions from interior spaces that are heated and/or mechanically cooled and are not applicable to the separation of interior conditioned spaces from each other.

B. Exterior doors and windows shall be designed to limit air leakage into or from the building envelope. Manufactured doors and windows shall have air infiltration rates not exceeding those shown in Table No. 53-D. Site-constructed doors and windows shall be sealed in accordance with 5305 (b)4C.

C. **Standard Air Leakage Control.** (i) These requirements shall apply to all buildings.

(ii) The following openings in the building envelope shall be caulked or otherwise sealed to limit infiltration: Around glazing and door frames, between the unit and the interior sheet rock or the rough framing'
Between all exterior wall sole plates and the structural floor, using two rows of caulking or an alternate approved procedure;
Over all framing joints where floors over conditioned spaces intersect exterior walls (e.g., at rim and band joists), using a high permeance infiltration barrier or alternate approved technique;
Around penetrations in the building envelope for ducts, plumbing, electrical and utilities in walls, ceilings and floors;
At all openings or joints in the ceiling membrane;
At the top and bottom of the mudsill (basements only and underfloor plenums);
At all other penetrations in the building envelope.

(iii) Electric outlet plate gaskets shall be installed or the boxes sealed on all electrical outlets in the exterior walls, ceiling or floor.

(iv) HVAC ducts shall be sealed at all joints and corners, at junctions between outlet registers and interior surfaces.

(v) Masonry and factory-built fireplaces and wood stoves shall be installed with the following: Tight-fitting, closeable metal or glass doors covering the entire opening of the firebox;
A combustion air intake from outside of the conditioned space directly into the firebox, at least 6 square inches in area, and equipped with a readily accessible, operable, and tight-fitting; and,
For masonry fireplaces only, a tight-fitting flue damper with a readily accessible manual control.

(vi) Fans or other systems exhausting air from the building to the outside shall be provided with backdraft or automatic dampers to limit air leakage.

**EXCEPTIONS:** Low rise R-1 and R-3 occupancies and other buildings less than 5000 sq ft shall be exempt from all of the requirements of Section 5305(b)4B and 5305(b)4C if: 1. The air exchange rate for the building is 7.0 air changes per hour or less when tested in accordance with RS-22 when depressurized to 50 pascals, or

2. The average air exchange rate for the building is .35 ACH or less as measured over a two week period of the heating season when tested in accordance with RS-23.

D. **Advanced Air Leakage Control.** These requirements may only be used for low rise R-1 and R-3 occupancies or other occupancies less than 5000 sq. ft. In addition to the requirements of Section 5305(b)4C, the following shall be provided:

(i) An air-to-air heat exchanger or exhaust air heat pump complying with the requirements of NWEC Standard #25 and #26.

(ii) Continuous Air Barrier: A continuous air barrier installed over all exterior ceilings, exterior floors, and exterior walls and sealed at all intersections of these components to create a continuous air barrier over the entire envelope of the building. Joints shall be structurally supported and sealed. Flexible sheet air infiltration barriers shall be lapped at least 6 inches at a framing member, and permanently fixed to prevent separation. All openings in the air barrier including rips and tears shall be sealed. Ceilings with plank and beam construction exposed to the conditioned space shall have the air barrier placed on top of the planking and sealed directly to the wall air barrier with compression gaskets, caulking or sealant as approved. Post and beam floors with decking shall have the air barrier placed on top of the decking and sealed directly to the wall air barrier with compression gaskets, caulking or sealant as approved.

**EXCEPTIONS:** 1. Buildings shall be exempt from all requirements of Section 5305(b)4B, 5305(b)4C and 5305(b)4D(ii) provided: 1.The air exchange rate for the building is 1.8 air changes per hour or less when tested in accordance with RS-22 when depressurized to 50 pascals; or

2. The average air exchange rate for the building is .1 ACH or less seasonal average without the heat recovery ventilation in operation or .35 ACH seasonal average with the heat recovery ventilation system in operation as measured over a two week period of the heating season when tested in accordance with RS-23.

(c) **Building Mechanical Systems.** 1. **General.** This section covers the determination of heating and cooling loads, design requirements, system and component performance, control requirements, insulating systems and duct construction.

**EXCEPTION:** Special applications for process loads may be exempted from the requirements of Section 5305(c) when approved by the building official.

2. **Calculations of Heating and Cooling Loads and System Sizing Limits.** The design parameters specified in section 5303 shall apply for all computations.

A. **Calculation Procedures.** Heating and cooling design loads for the purpose of sizing systems shall be determined in accordance with one of the procedures described in Chapters 25 and 26 of Standard RS-1 or an equivalent computation procedure.

B. **Infiltration.** Infiltration for heating and cooling design loads shall be calculated for all buildings using the methods identified above or other accepted engineering practice by the procedures in Chapter 22 of Standard RS-1.

C. **Space Heating and Cooling System Sizing Limits for Low Rise R-1 and R-3 Occupancies and other buildings less than 5000 sq.ft.** Building mechanical systems which provide space heating and/or space cooling shall be sized no greater than 150 percent of the design load as calculated above.

**EXCEPTION:** For heat pumps, compliance need only be demonstrated for either the space heating or space cooling system size. Where compliance is demonstrated for the space cooling system size, the supplementary heat element either shall be the smallest element available for that heat pump or the sum of the heat pump element plus the supplementary heat element shall not exceed 150 percent of the design heating load.

3. **Simultaneous Heating and Cooling.** Each temperature control zone shall include thermostatic controls installed and operated to sequence the use of heating and cooling energy to satisfy the thermal and/or humidity requirement of the zone. Controls shall prevent reheating (heating air that is cooler than system mixed air), recooling (cooling air that is warmer than the system mixed air), mixing or simultaneous supply of warm air (warmer than system return air mixed air) and cold air (cooler than system mixed air), or other simultaneous operation of heating and cooling systems to one zone. For the purposes of this section, system mixed air is defined as system return air mixed with the minimum ventilation air requirement by Section 5303(c)1.

**EXCEPTIONS:** 1. Variable air volume systems designed to reduce the air supply to each zone during periods of occupancy to the larger of the following:

a. 30% or less of the peak supply volume.

b. The minimum allowed to meet ventilation requirements of Section 5303(c)1.

c. 0.5 cfm/ft.$^2$ of zone conditioned area before reheating, recooling or mixing takes place. Consideration shall be given to supply air temperature reset control.

2. The energy for reheating, or providing warm air in mixing systems, is provided entirely from recovered energy that would otherwise be wasted, or from nondepletable energy sources. In addition, the system shall comply with Section 503.7 without exception.

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

4. Where special pressurization relationships or cross-contamination requirements are such that variable air volume systems are impractical, supply air temperatures shall be reset by representative building load or outside air temperature.

4. HVAC Equipment Performance Requirements. A. Equipment Components. (i) The requirements of this section apply to equipment and mechanical component performance for heating, ventilating and air-conditioning systems. Equipment efficiency levels are specified. Data furnished by the equipment supplier or certified under a nationally recognized certification program or rating procedure shall be used to satisfy these requirements. Equipment efficiencies shall be based on the standard rating conditions in Table No. 53-H, 53-I or 53-J as appropriate.

(ii) Where components from more than one manufacturer are assembled into systems regulated under this section, compliance shall be as specified in paragraphs 5305(c)4B through 5305(c)4F.

B. **HVAC System Heating Equipment Heat Pump-heating Mode.** Heat pumps whose energy input is entirely electric shall have a coefficient of performance (COP) heating, not less than the values in Table No. 53-E.

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

(ii) **Coefficient of performance (COP) heating.** The ratio of the rate of net heat out to the rate of total on-site energy input to the heat pump, 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 and heat from boilers).

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

(iii) **Supplementary Heater.** The heat pump shall be installed with a control to prevent supplementary hater operation when the operating 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.

A two-stage thermostat, which controls the supplementary heat on its second stage, 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, including, but not limited to, electric resistance, combustion heating or solar or stored-energy heating.

C. **Mechanical Ventilation.** Each mechanical ventilation system (supply and/or exhaust) shall be equipped with a readily accessible switch or other means for shutoff or volume reduction and shutoff when the ventilation is not required. Automatic or gravity dampers that close when the system is not operating shall be provided for outdoor air intakes and exhausts. There is no standard at this time for damper leakage. Automatic or manual dampers installed for the purpose of shutting off ventilation systems shall be designed with tight shutoff characteristics to minimize air leakage.

**EXCEPTIONS:** Manual dampers for outdoor air intakes may be used in the following cases: For R1 and R3 buildings; or when the fan system capacity is less than 3500 cfm.

D. **HVAC System Equipment, Electrically Operated, Cooling Mode.** HVAC system equipment as listed below, whose energy input in the cooling mode is entirely electric, shall have an energy efficiency ratio (EER) or a Coefficient of Performance (COP) cooling not less than values in Table No. 53-F.

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

**EXCEPTION:** These requirements do not apply to equipment used in areas such as supermarkets having open refrigerated food display cases or computers or other equipment contributing a large amount of heat to the area served.

(ii) **Coefficient of Performance (COP) Cooling.** The COP is the ration of the rate of net heat removal to the rate of total on-site energy input to the air conditioner expressed in consistent units and under designated rating conditions.

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

Total on-site energy input shall be determined by combining the energy inputs to all elements supplied with the package of the equipment including but not limited to compressor(s), compressor sump heater(s), pumps(s), supply-air fans(s), return-air fan(s), condenser-air fan(s), cooling-tower fan(s) and pump(s) and the HVAC system equipment control circuit.

E. **Applied HVAC System Components, Electrically Operated, Cooling Mode.** HVAC System components, as listed in Table NO. 53-6, whose energy input is entirely electric, shall have an energy efficiency ratio (EER) or a Coefficient of Performance (COP) cooling not less than the values in Table 53-6.

(i) **Coefficient of performance (COP) cooling:** The COP is the ration of the rate of net heat removal to the rate of total on-site energy input, expressed in consistent units and under designated rating conditions.

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

Total (on-site) energy input to the component shall be determined by combining the energy inputs to all elements and accessories as included in the component, including but not limited to, compressor(s), internal circulating pump(s), purge devices, and the HVAC system component control circuit.

5. **Transport Energy.** A. **All-air Systems.** The air transport factor for each all-air system shall be not less than 5.5. The factor shall be based on design system air flow for constant volume systems. The factor for variable air volume systems may be based on average conditions of operation. Energy for transfer

of air through heat recovery devices shall not be included in determining the factor; however, such energy shall be included in the evaluation of the effectiveness of the heat recovery system.

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

*Expressed in Btu/h or watts

For purposes of these calculations, Space Sensible Heat Removal is equivalent to the maximum coincident design sensible cooling load of all spaces served for which the system provides cooling. Fan Power Input is the rate of energy delivered to the fan prime mover.

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

6. **Balancing.** The HVAC system design shall provide an accessible means for balancing air and water systems. In doing so, the considerations shall include, but not be limited to, dampers, temperature and pressure test connections and balancing valves.

7. **Cooling with Outdoor Air (Economizer Cycle).** Each fan system shall be designed to use up to and including 100 percent of the fan system capacity for cooling with outdoor air automatically whenever its use will result in lower usage of new energy. Activation of economizer cycle shall be controlled by sensing outdoor air enthalpy or outdoor air dry-built temperature alone or alternate means approved by the building official.

**EXCEPTIONS:** Cooling with outdoor air is not required under any one or more of the following conditions: 1. The fan system capacity is less than 3,500 cfm or total cooling capacity is less than 90,000 Btu/h.

2. The quality of the outdoor air is so poor as to require extensive treatment of the air and approval by the building official.

3. The need for humidification or dehumidification requires the use of more energy than is conserved by the outdoor air cooling on an annual basis.

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

5. When energy recovered from an internal/external zone heat recovery system exceeds the energy conserved by outdoor air cooling on an annual basis.

6. When all space cooling is accomplished by a circulating liquid which transfers space heat directly or indirectly to a heat rejection device such as a cooling tower without use of a refrigeration system.

7. When the use of 100 percent outside air will cause coil frosting, controls may be added to reduce the quantity of outside air. However, the intent of this exception is to use 100 percent air in lieu of mechanical cooling when less energy usage will result and this exception applies only to direct expansion systems when the compressor(s) is running.

8. For dwelling portions of R-1 and R-3 occupancies.

8. **Controls.** A. **Temperature Control.** Each system shall be provided with at least one adjustable thermostat for the regulation of temperature. Each thermostat shall be capable of being set by adjustment or selection of sensors as follows:

(i) When used to control heating only: 55 to 75 degrees F.

(ii) When used to control cooling only: 70 to 85 degrees F.

(iii) When used to control both heating and cooling, it shall be capable of being set from 55 to 85 degrees F and shall be capable of operating the system heating and cooling in sequence. The thermostat and/or control system shall have an adjustable deadband of not less than 10 degrees F except as allowed by the second subparagraph of 5305(c)3C(v).

B. **Humidity Control.** If a system is equipped with a means for adding moisture to maintain specific selected relative humidities in space or zones, a humidistat shall be provided. Humidistats shall be capable of being set to prevent new energy from being used to produce space-relative humidity above 30 percent. When a humidistat is used in a system for controlling moisture removal to maintain specific 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 of less than 60 percent.

**EXCEPTION:** Special occupancies requiring different relative humidities may be permitted.

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

(ii) **Multifamily Dwellings.** For multifamily dwellings, each individual dwelling unit shall have at least one thermostat for regulation of space temperature. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each room. Spaces other than living units shall meet the requirements of 5305(c)8C(iii).

(iii) **Other types of buildings or occupancies.** At least one thermostat for regulation of space temperature shall be provided for: Each separate system; and,

Each separate zone as defined in section 5302. As a minimum, each floor of a building shall be considered as a separate zone. In a multistory building where the perimeter system offsets only the transmission losses of the exterior wall, an entire side of uniform exposure may be zoned separately. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each floor.

(iv) **Control setback and shutoff.** <u>One- and Two-Family and Multifamily Dwellings</u>: The thermostat required in 5305(c)8C(i) and 5305(c)8C(ii) or an alternate means, including, but not limited to, a switch or clock, shall provide a readily accessible manual or automatic means for reducing the energy required for heating and cooling during periods of nonuse or reduced need including, 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.

<u>Other buildings and occupancies</u>: Each system shall be equipped with a readily automatic means of shutting off or reducing the energy used during periods of nonuse or alternate uses of the building spaces or zones served by the system. Acceptable means include, but are not limited to:

Manually adjustable automatic timing devices.
Manual devices for use by operating personnel.
Automatic control systems.

9. **Air Handling Duct System Insulation.** Ducts, plenums and enclosures installed in or on buildings shall be thermally insulated as follows:

Duct systems, or portions thereof, shall be insulated to provide a thermal resistance, excluding air films of R-11 when installed outside the conditioned space. A weatherproof barrier shall be provided to protect any exterior insulation. All ducts for mechanical cooling shall provide a vapor retarder with a drycup rating not greater than 0.05 perm.

**EXCEPTIONS:** Duct insulation (except where required to prevent condensation) is not required in any of the following cases: 1. When the heat gain or loss of the ducts, without

insulation, will not increase the energy requirements of the building.
2. Within the HVAC equipment.
3. Exhaust air ducts.

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

A. High-pressure and medium-pressure ducts shall be leak tested in accordance with the applicable standards in section 5302 of this chapter with the rate of air leakage not to exceed the maximum rate specified in that standard.

B. When low-pressure supply air ducts are located outside of the conditioned space, all joints shall be sealed. All material used within the air plenum shall comply with the Uniform Mechanical Code.

C. Automatic or manual dampers installed for the purpose of shutting off outside air intakes for ventilation air shall be designed with tight shutoff characteristics to minimize air leakage.

11. **Piping Insulation.** A. All piping installed to serve buildings (and within) shall be thermally insulated in accordance with Table No. 53-K. For service hot water systems see Section 5305(d)7.

**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 and 100 degrees 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.

B. **Other Insulation Thickness.** Insulation thickness in Table No. 53-K 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 degree 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.

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

$$\frac{4.6 \times (\text{Table 5-10 Thickness})}{\text{Actual Resistance}} = \text{New Minimum Thickness}$$

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

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

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

(d) **Service Water Heating.** 1. **Scope.** The purpose of this section is to provide criteria for design and equipment selection that will produce energy savings when applied to service water heating.

2. **Water Heaters, Storage Tanks and Boilers.** A. **Performance Efficiency.** Electric storage water heaters shall meet the requirements of ASHRAE Standard 90A-80 and be so labeled.

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

B. **Insulation.** Heat loss from unfired hot-water storage tanks shall be limited to a maximum of 9.6 Btu/hr/ft of external tank surface area. The design ambient temperature shall be no higher than 65 degrees F.

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

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

$$(13.3\ pmd + 400)/n$$

determined by the fixture count method where:

pmd = probably maximum demand in gallons/hour as determined in accordance with Chapter 37 of Standard RS-11.

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

The standby loss is to be determined for a test period of 24 hour duration while maintaining a boiler water temperature of 90 degrees F above an ambient of 60 degrees F and a 5 foot stack on appliance.

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

3. **Automatic Controls.** Service water heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature

settings for the intended use. Temperature setting range shall be in accordance with Table 2 in Chapter 37 of Standard RS-11.

4. **Shutdown.** A separate switch shall be provided to permit turning off the energy supplied to electric service water heating systems.

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

B. **Pool Covers.** Heated swimming pools shall be equipped with an approved pool cover.

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

7. **Pipe Insulation.** For recirculating systems, piping heat loss shall be thermally insulated in accordance with Table 53-K for low temperature applications.

8. **Conservation of Hot Water.** A. **Showers.** Showers used for other than safety reasons shall be equipped with flow control devices to limit the maximum hot water discharge to 2.75 gpm rated at distribution pressures from 20 to 80 psi.

B. **Lavatories in Rest Rooms of Public Facilities shall:**

(i) Be equipped with outlet devices which limit the flow of hot water to a maximum of 0.5 gpm or be equipped with self-closing valves that limit delivery to a maximum of 0.25 gallons of hot water for recirculating systems and to a maximum of 0.50 gallons for nonrecirculating systems.

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

(ii) Be equipped with devices which limit the outlet temperature to a maximum of 110 degrees F.

(e) **Electrical Power and Lighting.** 1. **General.** Electrical power and lighting systems shall be designed to conserve energy as provided herein.

2. **Electrical Energy Consumption.** In multifamily dwellings, provision shall be made to determine the electrical energy consumed by each dwelling unit by separately metering individual dwelling units.

**EXCEPTION:** Motels, hotels, college dormitories and other transient facilities.

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

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

> **EXCEPTION:** R-3 occupancies and the dwelling portions of R-1 are exempt from the requirements of Section 5305(e)3.

A. **Budget Development.** (i) The installed lighting wattage for 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 subsection 5305(c)3B and the exterior budget calculated in accordance with subsection 5305(c)3D Lighting wattage includes lamp and ballast wattage.

> **EXCEPTION:** The interior lighting budget for office and sales (retail and wholesale) occupancies may be calculated using the procedures in Section 5310 when approved by the Building Official.

(ii) When insufficient information is known about the specific use of the building space, the budget shall be based on the apparent intended use of the building space.

B. **Building Interiors.** (i) The interior lighting budget shall be calculated by multiplying the gross floor area, in square feet, by the appropriate unit power budget, in watts per square foot, specified in Table No. 53-L.

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

> **EXCEPTION:** Where the following automatic lighting controls are installed for calculation purposes, the installed lighting wattage may be reduced by the following percentages:
> a. For occupant-sensing devices, energy savings of 30 percent

shall be allowed for any single space up to 250 square feet and enclosed by ceiling height partitions; classrooms, conference rooms, computer rooms, storage areas, corridors, or waiting rooms.

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

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

d. For daylighting controls with occupant-sensing devices, energy savings of 44 percent shall be allowed for any single space up to 250 square feet within daylit spaces, and enclosed by ceiling height partitions.

e. For occupant-sensing devices with lumen maintenance controls, energy savings of 37 percent shall be allowed for any single space up to 250 square feet and enclosed by ceiling height partitions.

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

- Stage lighting, lighting for art objects, entertainment, or audiovisual presentations where the lighting is an essential technical element for the function performed.
- Lighting for medical and dental tasks.
- Lighting in areas specifically designed for visually handicapped people.
- For restaurant occupancies, lighting for kitchens and food preparation areas.
- Power required for trickle-charging for battery powered emergency lighting.

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

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

A. **Switching requirements.** (i) All lighting controls, except automatic controls or those for special purpose applications which require trained operators or those which would pose a safety problem or a security hazard, shall be installed so as to be readily accessible to personnel occupying or using the lighting space.

(ii) The maximum lighting power that may be controlled from a single switch or automatic control shall not exceed that provided by a 20 ampere circuit loaded to no more than 80 percent. A master control may be installed provided the individual switches retain their capability to function independently.

(iii) All lighted spaces enclosed by walls or ceiling height partitions and with floor area less than two hundred fifty square feet shall be provided an individual, local lighting control or an occupant-sensing automatic control.

(iv) All lighted spaces with floor area greater than two hundred fifty square feet shall be provided with local controls to permit reducing the lighting by no more than one-half or occupant-sensing automatic controls.

(v) All building areas greater than 200 square feet where natural lighting is available shall be provided with individual local controls or daylight- or occupant-sensing automatic controls which permit control of lights independent of general area lighting. Either individual controls shall be provided for each row of luminaries parallel to a window wall or controls shall be provided for each row of luminaries parallel to a window wall or controls shall be provided to reduce the lighting in at least two steps to not more than one-half and to completely off in the natural lighting area.

For office and school occupancies, at a minimum, lighting serving a zone within 12 feet of a window wall or the zone between an interior wall and the window wall of less than 12 feet shall comply with this provision.

For retail occupancies, at least the row of luminaries nearest the window shall comply with this provision.

(vi) All display, exhibition or specialty lighting shall be controlled independently of general area lighting.

(vii) All exterior building lighting including facade lighting, parking lots, driveways, walkways, shall be furnished with automatic controls to reduce or turn off all lights during periods of non-use or daylight hours, except those required for safety and security. Sign lights shall be exempt from this provision.

## TABLE NO. 53-B
## COMPONENT U-VALUE REQUIREMENTS FOR LOW RISE R1 AND R3 OCCUPANCIES AND AND OTHER BUILDINGS LESS THAN 5000 SQ FT

| | Climate Zone | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Opaque ceiling | .032 | .032 | .021 |
| Opaque wall | .057 | .043 | .040 |
| Floor | .029 | .029 | .029 |
| Slab on grade[1] | .455 | .455 | .455 |
| Below grade wall[1] | .750 | .750 | .750 |
| Doors | .190 | .190 | .190 |
| Glazing[2] | .390 | .390 | .390 |

Reference glazing area = .15 x Conditioned Floor Area
Air leakage control - Standard (ACH = .35)

1. F-Values- See 5301(e) for definition
2. Glazing at 7.5 mph seasonal conditions

## TABLE NO. 53-C

## COMPONENT REQUIREMENTS FOR ALL BUILDINGS OTHER THAN LOW RISE R-1 AND R-3 OCCUPANCIES AND OTHER BUILDINGS LESS THAN 5000 SQ FT

| Component | Requirement |
|---|---|
| Space Conditioning System Type | Any |
| Nominal $U_o$ Value-Envelope | |
| Gross roof/ceiling | $U_o$ = .08 |
| Exterior walls in buildings with three stories or less | $U_o$ = .25 |
| More than three stories | $U_o$ = .30 |
| Floors over unconditioned space | $U_o$ = .05 |
| Below grade walls and heated slab on grade floors | R-10 |
| Unheated slab on grade floors | R-8 |
| AIR LEAKAGE CONTROL PACKAGE | STANDARD |

TABLE NO. 53-D

ALLOWABLE AIR LEAKAGE RATES[1]

| AIR LEAKAGE CONTROL PACKAGE | WINDOWS (cfm per lineal ft of operable sash crack) | RESIDENTIAL DOORS[2] SWINGING (cfm per lin ft of operable sash crack) | RESIDENTIAL DOORS[2] SLIDING (cfm per sq ft of door) | NONRESIDENTIAL DOORS SWINGING, SLIDING, REVOLVING (cfm per lin ft of crack) |
|---|---|---|---|---|
| Standard | 0.3 | 0.2 | 0.25 | 11.0 |
| Advanced | 0.2 | 0.2 | 0.10 | 11.0 |

1- When tested at a pressure differential of 1.567 lb/ft², which is equivalent to the impact pressure of a 25 mph wind.

2- Compliance with the criteria for air leakage shall be determined by Standard RS-2

TABLE NO. 53-E

MINIMUM COP AND HPSF FOR HEAT PUMPS, HEATING MODE[1]

| SOURCE AND OUTDOOR TEMPERATURE (F) | MINIMUM COP LOW RISE R1 & R3 | OTHER OCC | MIN HSPF |
|---|---|---|---|
| Air Source-47DB/43WB | 2.7 | 2.7 | |
| Air Source-17DB/15WB | 2.0 | 1.8 | |
| Air Source | --- | --- | 6.8 |
| Water Source-60 entering | 3.0 | 3.0 | |

1- When tested at the standard rating specified in Table 53-H.

TABLE NO. 53-F

MINIMUM EER AND COP FOR ELECTRICALLY DRIVEN HVAC SYSTEM EQUIPMENT COOLING[1,2]

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

1- When tested at the standard rating conditions specified in Table No. 53-I.

2- The Department of Energy has established required test procedures for single-phase air-cooled residential central air conditioners under 19 KW (65,000 Btu/hr) in capacity, which have been incorporated into ARI Standard 210-79.

TABLE NO. 53-6

MINIMUM EER AND COP FOR ELECTRICALLY DRIVEN HVAC SYSTEM COMPONENTS[1]

WATER CHILLING PACKAGES

CONDENSING MEANS

| TYPE OF COMPONENT | COMPRESSOR TYPE | AIR EER | AIR COP | WATER EER | WATER COP | EVAPORATIVE EER | EVAPORATIVE COP |
|---|---|---|---|---|---|---|---|
| Condenser Included | Centrifugal or rotary | 8.00 | 2.34 | 13.80 | 4.04 | -- | -- |
| | Reciprocating | 8.40 | 2.36 | 12.00 | 3.51 | -- | -- |
| Condenserless water chillers | Positive displacement | 9.50 | 2.78 | 11.60 | 3.40 | -- | -- |
| | Reciproc. | 9.90 | 2.90 | 12.00 | 3.51 | -- | -- |
| Compressor and condenser units 65,000 Btu/hr (19,000 watts) and over[2] | Positive displacement | 9.50 | 2.78 | 12.50 | 3.66 | 12.50 | 3.66 |

HYDRONIC HEAT PUMPS

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

1- When tested at the standard rating conditions specified in Table No. 53-J.

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

## TABLE NO. 53-H

### HVAC SYSTEM HEATING EQUIPMENT (HEAT PUMPS)
### ELECTRICALLY OPERATED STANDARD RATING CONDITIONS

| CONDITIONS | | TYPE<br>AIR SOURCE | | WATER SOURCE |
|---|---|---|---|---|
| Air entering equipment | dF | 70DB | 70DB | 70DB |
| Outdoor unit ambient | dF | 47DB/43WB | 17DB/15WB | -- |
| Entering water temp. | dF | -- | -- | 60 |
| Water flow rate | | -- | -- | As used in cooling |

Standard ratings are at sea level.

## TABLE NO. 53-I

### HVAC SYSTEM EQUIPMENT,
### ELECTRICALLY DRIVEN
### STANDARD RATING CONDITIONS--COOLING

| | | TEMPERATURES | | | |
|---|---|---|---|---|---|
| | | DB | WB | INLET | OUTLET |
| Air entering equipment | dF | 80 | 67 | -- | -- |
| Condenser ambient (air cooled) | dF | 95 | 75 | -- | -- |
| Condenser water (water cooled) | dF | -- | -- | 85 | 95 |

Standard ratings are at sea level.

TABLE NO. 53-J

APPLIED HVAC SYSTEM COMPONENTS
ELECTRICALLY DRIVEN STANDARD RATING CONDITIONS--COOLING

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

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

TABLE NO. 53-K

MINIMUM PIPE INSULATION

| PIPING SYSTEM TYPES | FLUID TEMP. RANGE, F | INSULATION THICKNESS IN INCHES FOR PIPE SIZES[1] | | | | | |
|---|---|---|---|---|---|---|---|
| | | RUN OUTS - 2" | 1" & less | 1.25" -2" | 2.5" - 4" | 5" -6" | 8"& lar. |
| HEATING & HOT WATER SYSTEMS | | | | | | | |
| Steam & hot water | | | | | | | |
| High pressure/temp | 306-450 | 1.5 | 2.5 | 2.5 | 3.0 | 3.5 | 3.5 |
| Med pressure/temp | 251-305 | 1.5 | 2.0 | 2.5 | 2.5 | 3.0 | 3.0 |
| Low pressure/temp | 201-250 | 1.0 | 1.5 | 1.5 | 2.0 | 2.0 | 2.0 |
| Low temperature | 100-200 | .5 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| Steam condensate (for feed water) | Any | 1.0 | 1.0 | 1.5 | 2.0 | 2.0 | 2.0 |
| COOLING SYSTEMS | | | | | | | |
| Chilled water | 40-55 | .5 | .5 | .75 | 1.0 | 1.0 | 1.0 |
| Refrigerant/brine | Below 40 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 |

1- For piping exposed to exterior air, increase thickness by .5".
2- Runouts not exceeding 12 feet in length to individual units.

TABLE NO. 53-L
LIGHTING POWER BUDGET

| OCCUPANCY GROUP | OCCUPANCY DESCRIPTION | LIGHTING POWER BUDGET (watts/ft²) |
|---|---|---|
| A-1 | Assembly w/stage: occupancy of 1000+ | 1.1 |
| A-2 | Assembly w/stage: occupancy < 1000 | 1.1 |
| A-2.1 | Assembly w/o stage, occupancy of 300 or more other than B-2 and E | 1.1 |
| A-3 | Assembly w/o stage: occupancy of less than 300 other than B-2 and E | 1.1 |
| | Drinking and dining establishment | 1.85 |
| A-4 | Stadiums, reviewing stands and amusement park structures not included in A or B-1, B-2 and B-3 | 1.1 |
| A-5 | Stage Lighting | Exempt |
| B-1 | Gasoline and service stations: includes the office, waiting room and pump islands plus 5' on each side of the island | 2.0 |
| | Storage garages | 0.3 |
| B-2 | Office buildings, wholesale stores, municipal police and fire stations | 1.5 |
| | Retail stores | |
| | - Less than 1000 ft² | 4.5 |
| | - 1000-6000 ft² | 3.5 |
| | - 6000-20,000 ft² | 2.5 |
| | - over 20,000 ft2 | 1.5 |
| | Drinking and dining establishments: occ load of less than 50 | 1.85 |
| | Work shops using material not highly flammable or combustible | 2.0 |
| | Storage and warehouses | 0.7 |
| B-3 | Aircraft hangars | 0.7 |
| | Open parking garages | 0.3 |
| B-4 | Ice plants, power plants, pumping plants, cold storage and creameries | 1.0 |
| | Factories and workshops | 2.0 |
| | Storage | 0.7 |
| | Sales rooms | 2.0 |
| | Shipyard structures | 0.7 |
| E-1 | Schools and day-care centers | 2.0 |
| E-2 | Audio-visual presentation lighting | Exempt |
| H-1 | Storage | 0.7 |
| | Handling | 2.0 |

TABLE NO. 53-L (continued)
LIGHTING POWER BUDGET

| OCCUPANCY GROUP | OCCUPANCY DESCRIPTION | LIGHTING POWER BUDGET (watts/ft$^2$) |
|---|---|---|
| H-2 | Storage | 0.7 |
| | Handling, dry cleaning plants, paint stores | 2.0 |
| | Paint shops and spray painting rooms | 2.5 |
| H-3 | Warehouses | 0.7 |
| | Other | 2.0 |
| H-4 | Auto repair and body shops | 2.0 |
| | Paint spray booths | 5.0 |
| H-5 | Aircraft repair hangars | 2.0 |
| I-1 | Institutions | 2.0 |
| I-2 | Administrative support services | 2.0 |
| I-3 | Nursing areas | 2.0 |
| I-4 | Diagnostic, treatment, food service task lighting | Exempt |
| R-1 | Dwelling unit portions | Exempt |
| | Other than dwelling unit portions | Refer to app.occ. |
| R-3 | Dwelling unit portions | Exempt |
| | Other than dwelling unit portions | Refer to app.occ. |

**Building Design by Prescriptive Requirements Approach**

**Sec. 5306.** (a) **Scope.** The provisions of this Chapter are applicable only to low rise R-1 and R-3 Occupancy buildings, and other buildings less than 5000 sq. ft., that use electric energy for heating and/or cooling. The building shall comply with all the requirements of section 5305 except for the modifications herein specified.

(b) Building Envelope Requirements. 1. **General.** The building envelope requirements of this Chapter may be met by installing one of the prescriptive packages in Tables No. 53-M, 53-N, 53-O for low rise R-3 Occupancy or 53-P for low rise R-1 and other buildings less than 5000 sq.ft. Installed components shall meet the following requirements:

2. **Roof/ceiling.** Ceilings below vented attics and vaulted ceilings shall be insulated to not less than the nominal R-value specified for ceilings in Tables No. 53-M, 53-N, 53-O, or 53-P, as applicable. Advanced framing shall require that the nominal R-value be maintained to the outside of the exterior building envelope.

3. **Above grade exterior walls** shall be insulated to not less than the nominal R-value specified in Tables No. 53-M, 53-N, 53-O, or 53-P, as applicable. The R-value shall be the total value for insulation in stud cavities and/or insulated sheathing. Advanced framing shall consist of a minimum of 2x studs at 24" o.c. and two stud corners. Headers shall be insulated with rigid insulation of a minimum nomial R-value of R-4/inch.

4. **Below grade exterior walls** surrounding conditioned space shall be insulated to not less than the nominal R-value specified for below grade walls in Tables No. 53-M, 53-N, 53-O, or 53-P as applicable.

5. **Slab-on-Grade floors** shall be insulated along their perimeter to not less than the nominal R-value specified for slab-on-grade floors in Tables No. 53-M, 53-N, 53-O, or 53-P as applicable.

6. **Floors over unconditioned enclosed spaces,** such as vented crawl spaces, unconditioned basements, and parking garages that are not mechanically ventilated shall be insulated to not less than the nominal R-value shown for floors over unconditioned spaces, enclosed area in Tables No. 53-M, 53-N, 53-O, or 53-P as applicable.

Floors over unconditioned spaces exposed to exterior ambient conditions such as building overhangs, open parking areas and enclosed parking areas which are mechanically ventilated shall be insulated to not less than the nominal R-value shown for unconditioned spaces, exposed area Table No. 53-P.

7. **Exterior Doors.** A. All exterior doors shall comply with the infiltration specifications set forth in Table No. 53-D.

B. Exterior doors without glazing shall have the maximum U-value shown in Table No. 53-P as applicable.

**EXCEPTIONS:** 1. Insulated metal doors which are 1-3/4 inches thick shall be deemed to have a nominal U-value of .19; provided that they are thermally broken, have their cores filled with urethane, polystyrene, polyisocyanurate foam or approved equal.

2. Wood doors which are 1-3/4 inches thick shall be deemed to have a nominal U-value of .4; provided that they have solid cores and do not have panels less than 1-1/8 inches thick.

8. **Glazing.** A. The total glazed area shall not exceed the percentage of gross floor area specified in Tables No. 53-M, 53-N, 53-O, or 53-P as applicable.

B. All glazing shall have a tested U-value not greater than that specified in Tables No. 53-M, 53-N, 53-O, or 53-P as applicable.

**EXCEPTIONS:** 1. Glazed areas up to a maximum of 4 square feet may be exempted from the thermal transmittance (U) value requirement.

2. Skylights and glazing in exterior doors which exceed the U-value specified for glazing in Tables No. 53-M through 53-P as applicable may be installed provided their area is doubled when calculating compliance with the maximum glazing area requirements.

3. Permanently installed insulated shutters or shades with a maximum U-value of 0.2 (R-value of five) may be used to achieve U values of 0.40 or lower when installed in combination with glazing having a maximum U value of 0.50.

C. Effective solar glazing shall not be less than the percentage of gross floor area specified in Tables No. 53-M, 53-N, or 53-O as applicable and shall comply with all requirements of this section.

(i) The glazing area shall be oriented within 45 degrees of true south with no more than 60 percent of the area facing between 31 and 45 degrees of true south.

(ii) The glazing shall be mounted at least 60 degrees up from the horizontal.

(iii) The glazing shall give a transmission coefficient greater than or equal to 0.80 for visible light or greater than equal to 0.73 for total solar radiation for a single pane.

(iv) Documentation in the form of a sun chart, photograph or other approved evidence demonstrating that the glazing area oriented within 30 degrees of true south shall not be shaded for at least 3 hours between the hours of

10:00 a.m. and 2:00 p.m. standard time on January 21 and March 21.

(v) An easement or other means of guaranteeing solar access is filed with the building department.

D. **Thermal Mass.** Thermal mass required for option III in Tables No. 53-M, 53-N, and 5-O shall comply with the following minimum requirements.

(i) Thermal mass shall be distributed in the floors, walls and/or ceiling and shall be directly exposed to the conditioned space.

**EXCEPTION:** 1. Thermal mass covered by finish materials with a combined R-value no greater than 1.0

2. Storage mediums not within the space containing the qualifying glazing shall be provided with an approved natural or mechanical means of transferring the heat to the heat storage medium.

(ii) The heat storage capacity shall be a minimum of 10 Btu/f-hr per sq. ft. of conditioned floor area.

(iii) The heat storage capacity shall be calculated using EQ 53-6 or standard engineering practice.

HS = D x SH x V...................... Equation 53-6

**WHERE:**

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

V = Volume of heat storage components.

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

(c) **Air Leakage.** The minimum air leakage control measures shall be those specified for the prescriptive package shown in Tables No. 53-M, 53-N, 53-O, or 53-P as applicable.

(d) **Building Mechanical Systems. 1. Heat Pump.** Air-to-air, ground-to-air, or water-to-air heat pumps installed to comply with a prescriptive package set forth in Tables No. 53-M, 53-N, and 53-O as determined by an analysis consistent with Section 5.2 of RS-22.

**EXCEPTION:** Air-to-air heat pumps which are listed in the Air Conditioning and Refrigeration Institute's (ARI) Directory of Certified Unitary Air-Conditioners, Unitary Air Source Heat Pumps and Sound Rated Outdoor Equipment as having HSPF of 6.8 Btu/watt or greater and a Low Temperature

Coefficient of Performance (COP) of not less than 2.0 shall be considered to comply with the requirements of Tables 53-M, 53-N, and 53-O.

TABLE NO. 53-M
LOW RISE R-3 OCCUPANCIES
COMPONENT PRESCRIPTIVE OPTIONS FOR ZONE 1

| COMPONENT | | OPTIONS | | | |
|---|---|---|---|---|---|
| INSULATION MINIMUM NOMINAL R-VALUE | | I | II | III | IV |
| Ceiling[1] | Flat | R38 | R38 | R38 | R38 |
| | Vaulted | R38 | R38 | R38 | R38 |
| Wall[1] | | R19A | R24A | R19 | R19 |
| Below grade walls | Interior | R19 | R19 | R19 | R19 |
| | Exterior | R10 | R10 | R10 | R10 |
| Floor over unconditioned space | | R30 | R19 | R19 | R19 |
| Slab on grade perimeter | | R10 | R10 | R10 | R10 |
| DOORS: Maximum U-value | | .19 | .19 | .19 | .22 |
| GLAZING: | | | | | |
| Maximum tested U-value | | .40 | .40 | .50 | .60 |
| Maximum glazing area (% of floor) | | 15% | 15% | 18% | 15% |
| Minimum effective solar glazing area | | -- | -- | 10% | -- |
| Minimum thermal mass[2] | | -- | -- | 10 | -- |
| HEAT PUMP MINIMUM HSPF | | -- | -- | -- | 6.8 |
| AIR LEAKAGE CONTROL[3] | | Std | Std | Std | Std |

"-" indicates no requirement
1- A indicates advanced framing.
2- Minimum thermal mass in Btu/°F-ft$^2$.
3- Std. indicates Standard Air Leakage Control. See Section 5305(b)4.

NOTE: Each of the prescriptive options is intended to describe a building with a specific feature as noted below:

| | |
|---|---|
| Option I | Base Case |
| Option II | Well Insulated Walls |
| Option III | Passive Solar |
| Option IV | Heat Pump |

**TABLE NO. 53-N**
**LOW RISE R-3 OCCUPANCY**
**COMPONENT PRESCRIPTIVE OPTIONS FOR ZONE 2**

| COMPONENT | | OPTIONS | | | |
|---|---|---|---|---|---|
| **INSULATION MINIMUM NOMINAL R-VALUE** | | **I** | **II** | **III** | **IV** |
| Ceiling[1] | Flat | R38 | R49A | R38 | R38 |
| | Vaulted | R38 | R38 | R38 | R38 |
| Wall[1] | | R24A | R19A | R19 | R19 |
| Below grade walls | Interior | R19 | R19 | R19 | R19 |
| | Exterior | R12 | R12 | R12 | R12 |
| Floor over unconditioned space | | R30 | R30 | R30 | R30 |
| Slab floor perimeter | | R10 | R10 | R10 | R10 |
| DOORS: Maximum U-value | | .19 | .19 | .19 | .22 |
| GLAZING: | | | | | |
| Maximum tested U-value | | .40 | .40 | .40 | .50 |
| Maximum glazing area (% of floor) | | 15% | 15% | 18% | 15% |
| Minimum effective solar glazing area | | -- | -- | 10% | -- |
| Minimum thermal mass[2] | | -- | -- | 10 | -- |
| HEAT PUMP MINIMUM HSPF: | | -- | -- | -- | 6.8 |
| AIR LEAKAGE CONTROL[3] | | Std | Std | Std | Std |

1- Zone I. II indicates advanced framing.
2- Minimum thermal mass in Btu/deg F-ft$^2$.
3- Standard indicates Standard Air Leakage Control. See Section 5305(b)4.

NOTE: Each of the prescriptive options is intended to describe a building with a specific feature as noted below:

Option I Base Case
Option II Well Insulated Ceiling
Option III Passive Solar
Option IV Heat Pump

TABLE NO. 53-Q
LOW RISE R-3 OCCUPANCY
COMPONENT PRESCRIPTIVE OPTIONS FOR ZONE 3

| COMPONENT | | OPTIONS | | | |
|---|---|---|---|---|---|
| INSULATION MINIMUM NOMINAL R-VALUE | | I | II | III | IV |
| Ceiling[1] | Flat | R49A | R38 | R38 | R38 |
| | Vaulted | R38 | R38 | R38 | R38 |
| Wall[1] | | R26A | R30A | R24 | R19 |
| Below grade walls | Interior | R19 | R19 | R19 | R19 |
| | Exterior | R15 | R15 | R15 | R15 |
| Floor over unconditioned space | | R30 | R30 | R30 | R30 |
| Slab floor perimeter | | R10 | R10 | R10 | R10 |
| DOORS: Maximum U-value | | .19 | .19 | .19 | .22 |
| GLAZING: | | | | | |
| Maximum tested U-value | | .40 | .40 | .40 | .40 |
| Maximum glazing area (% of floor) | | 15% | 15% | 18% | 15% |
| Minimum effective solar glazing area | | -- | -- | 10% | -- |
| Minimum thermal mass[2] | | -- | -- | 10 | -- |
| HEAT PUMP MINIMUM HSPF: | | -- | -- | -- | 6.8 |
| AIR LEAKAGE CONTROL[3] | | Std | Std | Std | Std |

"-" indicates no requirement
1- A indicates advanced framing.
2- Minimum thermal mass in Btu/°F-ft².
3- Std. indicates Standard Air Leakage Control. See Section 5305(b)4.
NOTE: Each of the prescriptive options is intended to describe a building with a specific feature as noted below:

Option I Base Case
Option II Well Insulated Walls
Option III Passive Solar
Option IV Heat Pump

TABLE NO. 53-P
LOW RISE R-1 OCCUPANCIES AND
OTHER OCCUPANCIES LESS THAN 5000 SQ FT
COMPONENT PRESCRIPTIVE STANDARDS

| COMPONENT | | CLIMATE ZONE 1 OPT A | 1 OPT B | 2 OPT A | 2 OPT B | 3 OPT A | 3 OPT B |
|---|---|---|---|---|---|---|---|
| INSULATION MINIMUM NOMINAL R-VALUE | | | | | | | |
| Ceiling1 | Flat | R38 | R38 | R38 | R38 | R49A | R49A |
| | Vaulted | R38 | R38 | R38 | R38 | R38 | R38 |
| Wall[1] | | R19A | R19 | R24A | R24 | R26A | R26 |
| Below grade wall | Interior | R19 | R19 | R19 | R19 | R19 | R19 |
| | Exterior | R10 | R10 | R12 | R12 | R12 | R12 |
| Floor over uncond. space | | | | | | | |
| | Enclosed | R30 | R30 | R30 | R30 | R30 | R30 |
| | Exposed | R38 | R38 | R38 | R38 | R38 | R38 |
| Slab floor perimeter | | R10 | R10 | R10 | R10 | R10 | R10 |
| DOORS: Maximum U-value | | .19 | .19 | .19 | .19 | .19 | .19 |
| GLAZING: | | | | | | | |
| Maximum tested U-value | | .40 | .50 | .40 | .50 | .40 | .50 |
| Maximum glazing area (% of floor) | | 15% | 11% | 15% | 11% | 15% | 11% |
| AIR LEAKAGE[2] | | Std | Std | Std | Std | Std | Std |

"-" indicates no requirement
1- A indicates advanced framing.
2- Std. indicates Standard Air Leakage Control. See Section 5305(b)4.

**Building Design by Component Point System**

**Sec. 5307 (a) Scope.** The provisions of this Chapter are applicable only to low rise R-3 Occupancies that use electric energy for heating and/or cooling. Buildings shall comply with all the requirements of section except for the modifications herein specified.

(b) **Calculation Procedure. 1. Compliance.** The component point system allows modification of the prescribed conservation levels specified in Table No. 53-B.

For each building component, the corresponding point value of that component shall be taken from Table No. 53-Q through 53-V as applicable. Negative points correspond to increased energy requirements, and positive points to reduce requirements. For components which comply with the base case conservation level, the point value will be zero. Calculations shall comply with the procedures listed herein.

> **EXCEPTION:** No trade-off shall be permitted for below grade walls or slab on grade. The minimum R-values shall be as specified in Table No. 53-M, 53-N or 53-O as applicable, for the base case condition.

Buildings shall be deemed to comply with requirements of this Chapter if the total point value for all components is greater than or equal to zero.

2. **Calculation Procedure. A. Components with Multiple Conservation Levels.** Points for cases of multiple conditions for a given component shall be calculated as an area weighted average.

$$P = [A_1P_1 + A_2P_2 + \ldots]/A$$

WHERE:

$P$ = weighted average component points
$P_1, P_2, \ldots$ = points for component condition 1, 2,....
$A_1, A_2, \ldots$ = area of component for condition 1, 2,....
$A$ = total component area.

B. **Interpolation of Point Values.** Component construction types which fall between the conservation levels included in Table No. 53-Q through 53-V may be linearly interpolated.

TABLE NO. 53-Q
CEILING POINTS

Flat Ceilings

| Nominal R-Value | Zone 1 Std | Zone 1 Adv | Zone 2 Std | Zone 2 Adv | Zone 3 Std | Zone 3 Adv |
|---|---|---|---|---|---|---|
| 19 | -53 | -43 | -72 | -59 | -128 | -113 |
| 30 | -14 | -2 | -19 | -2 | -65 | -46 |
| 38 | 0 | 14 | 0 | 19 | -43 | -21 |
| 49 | 11 | 26 | 15 | 36 | -25 | 0 |
| 60 | 17 | 35 | 24 | 48 | -15 | 14 |

Vaulted Ceilings

| Nominal R-Value | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| 19 | -71 | -96 | -114 |
| 25 | -38 | -52 | -61 |
| 30 | -19 | -27 | -32 |
| 38 | 0 | 0 | 0 |
| 45 | 11 | 15 | 17 |
| 49 | 21 | 29 | 35 |

TABLE NO. 53-R
ABOVE GRADE WALLS POINTS
(W/WO INSULATION SHEATHING)

| | | Single Stud Walls | | | | | |
|---|---|---|---|---|---|---|---|
| | | Zone 1 | | Zone 2 | | Zone 3 | |
| Nominal | Sheathing | Framing | | Framing | | Framing | |
| R-Value | R-Value | Std | Adv | Std | Adv | Std | Adv |
| 11 | 4 | -20 | -15 | -67 | -60 | -90 | -82 |
| | 5 | -11 | -7 | -54 | -49 | -75 | -68 |
| | 6 | -3 | 1 | -43 | -38 | -62 | -56 |
| | 7 | 4 | 8 | -33 | -29 | -50 | -45 |
| | 8 | 11 | 13 | -25 | -21 | -40 | -35 |
| | 9 | 16 | 19 | -17 | -14 | -31 | -27 |
| | 10 | 21 | 24 | -10 | -7 | -22 | -19 |
| | 11 | 26 | 28 | -4 | -1 | -15 | -12 |
| | 12 | 30 | 32 | 2 | 5 | -8 | -5 |
| 13 | 4 | -9 | -4 | -52 | -45 | -72 | -63 |
| | 5 | -1 | 4 | -41 | -34 | -59 | -51 |
| | 6 | 6 | 10 | -31 | -25 | -48 | -41 |
| | 7 | 12 | 16 | -23 | -18 | -37 | -31 |
| | 8 | 18 | 21 | -15 | -10 | -28 | -23 |
| | 9 | 23 | 26 | -8 | -4 | -20 | -15 |
| | 10 | 27 | 30 | -2 | 2 | -13 | -8 |
| | 11 | 31 | 34 | 4 | 7 | -6 | -2 |
| | 12 | 35 | 37 | 9 | 12 | 0 | 4 |
| 19 | 0 | -16 | 0 | -62 | -40 | -83 | -57 |
| | 1 | -6 | 7 | -48 | -30 | -67 | -46 |
| | 2 | 2 | 13 | -37 | -21 | -54 | -36 |
| | 3 | 9 | 19 | -27 | -13 | -42 | -27 |
| | 4 | 16 | 24 | -18 | -6 | -32 | -18 |
| | 5 | 21 | 29 | -11 | 0 | -23 | -11 |
| | 6 | 26 | 32 | -4 | 5 | -15 | -4 |
| | 7 | 30 | 35 | 2 | 9 | -8 | 0 |
| | 8 | 34 | 40 | 8 | 15 | -1 | 7 |
| | 9 | 38 | 43 | 13 | 20 | 4 | 12 |
| | 10 | 41 | 45 | 17 | 24 | 10 | 17 |
| | 11 | 44 | 48 | 22 | 27 | 15 | 21 |
| | 12 | 47 | 51 | 26 | 31 | 19 | 25 |
| 22 | 0 | -5 | 11 | -47 | -24 | -66 | -39 |
| | 1 | 4 | 18 | -35 | -15 | -51 | -29 |
| | 2 | 11 | 23 | -24 | -8 | -39 | -20 |
| | 3 | 18 | 28 | -15 | -1 | -29 | -12 |
| | 4 | 23 | 32 | -8 | 5 | -20 | -5 |
| | 5 | 28 | 36 | -1 | 10 | -12 | 1 |
| | 6 | 32 | 39 | 5 | 15 | -5 | 7 |
| | 7 | 36 | 43 | 11 | 19 | 2 | 12 |
| | 8 | 40 | 45 | 16 | 24 | 8 | 17 |

## TABLE NO. 53-R (continued)
## WALLS (ABOVE GRADE) POINTS

### Single Stud Walls

| Nominal R-Value | Sheathing R-Value | Zone 1 Framing Std | Zone 1 Framing Adv | Zone 2 Framing Std | Zone 2 Framing Adv | Zone 3 Framing Std | Zone 3 Framing Adv |
|---|---|---|---|---|---|---|---|
| 22 | 9 | 43 | 48 | 20 | 27 | 13 | 22 |
| | 10 | 46 | 51 | 24 | 31 | 18 | 26 |
| | 11 | 49 | 53 | 28 | 34 | 22 | 29 |
| | 12 | 51 | 55 | 32 | 37 | 27 | 33 |

### Double Stud Walls

| Nominal R-Value | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| 30 | 46 | 24 | 18 |
| 33 | 56 | 39 | 35 |
| 38 | 63 | 48 | 46 |
| 41 | 67 | 54 | 53 |

### Strap Walls

| Nominal R-Value | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| 27 | 31 | 3 | -7 |
| 30 | 37 | 12 | 4 |

---

## TABLE NO. 53-S
## FLOORS OVER UNCONDITIONED SPACES POINTS

| Nominal R-Value | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| 11 | -60 | -82 | -96 |
| 19 | -24 | -33 | -39 |
| 25 | -9 | -12 | -14 |
| 30 | 0 | 0 | 0 |
| 38 | 11 | 15 | 17 |

TABLE NO. 53-T
DOOR POINTS

| Description | Zone 1 | with Storm | Zone 2 | with Storm | Zone 3 | with Storm |
|---|---|---|---|---|---|---|
| Metal, solid urethane core flush w/TB | 0 | 1 | 0 | 2 | 0 | 2 |
| Metal, 1-1/8" panel urethane core TB | -2 | 1 | -3 | 1 | -4 | 1 |
| Metal, ureth core flush TB w/double glass | -5 | -1 | -7 | -2 | -8 | -2 |
| Metal, 1-1/8" pnl ureth TB w/dbl glass | -7 | -2 | -9 | -3 | -11 | -4 |
| Wood, solid core flush | -10 | -4 | -14 | -6 | -17 | -7 |
| Metal, ureth core flush TB w/single glass | -12 | -5 | -16 | -7 | -19 | -8 |
| Wood, solid core flush w/dbl glass | -13 | -6 | -18 | -8 | -21 | -10 |
| Metal, 1-1/8" pnl ureth TB w/sngl glass | -13 | -6 | -18 | -8 | -21 | -10 |
| Wood, 1-1/8" panel | -15 | -7 | -20 | -9 | -24 | -11 |
| Wood, 1-1/8" panel w/ dbl glass | -18 | -9 | -25 | -12 | -29 | -14 |
| Wood, solid core flush w/sngl glass | -20 | -10 | -27 | -13 | -32 | -15 |
| Wood, hollow core flush | -20 | -10 | -27 | -13 | -32 | -15 |
| Wood, 7/16" panel w/ dbl glass | -23 | -11 | -31 | -15 | -36 | -18 |
| Wood, 7/16" panel | -26 | -13 | -35 | -17 | -41 | -20 |
| Wood, hollow core flush w/sngl glass | -27 | -13 | -37 | -17 | -43 | -20 |
| Wood, 1-1/8" panel w/ sngl glass | -31 | -14 | -42 | -19 | -49 | -22 |
| Wood, 7/16" panel w/ sngl glass | -35 | -16 | -47 | -22 | -56 | -26 |

TABLE NO. 53-U
GLAZING POINTS

Glazing Percentage (% of Floor Area)

| U Value | Zone 1 9% | Zone 1 12% | Zone 1 15% | Zone 1 18% | Zone 2 9% | Zone 2 12% | Zone 2 15% | Zone 2 18% | Zone 3 9% | Zone 3 12% | Zone 3 15% | Zone 3 18% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .20 | 63 | 71 | 78 | 83 | 87 | 99 | 107 | 113 | 115 | 122 | 127 | 131 |
| .22 | 58 | 65 | 71 | 74 | 80 | 90 | 97 | 101 | 107 | 112 | 115 | 116 |
| .24 | 53 | 59 | 63 | 65 | 74 | 81 | 86 | 88 | 99 | 101 | 102 | 101 |
| .26 | 48 | 52 | 55 | 56 | 67 | 72 | 75 | 76 | 91 | 91 | 89 | 86 |
| .28 | 43 | 46 | 47 | 47 | 60 | 64 | 65 | 63 | 83 | 80 | 76 | 71 |
| .30 | 38 | 40 | 40 | 38 | 53 | 55 | 54 | 51 | 75 | 70 | 64 | 56 |
| .32 | 34 | 33 | 32 | 29 | 47 | 46 | 43 | 38 | 67 | 60 | 51 | 41 |
| .34 | 29 | 27 | 24 | 20 | 40 | 37 | 32 | 25 | 59 | 49 | 38 | 25 |
| .36 | 24 | 20 | 16 | 10 | 33 | 29 | 22 | 12 | 51 | 39 | 25 | 10 |
| .38 | 19 | 14 | 8 | 1 | 27 | 20 | 11 | 0 | 43 | 29 | 13 | -5 |
| .40 | 14 | 8 | 0 | -9 | 20 | 11 | 0 | -13 | 36 | 18 | 0 | -20 |
| .42 | 9 | 1 | -8 | -18 | 13 | 2 | -11 | -26 | 28 | 8 | -13 | -35 |
| .44 | 4 | -5 | -16 | -28 | 7 | -7 | -22 | -39 | 20 | -2 | -25 | -50 |
| .46 | -1 | -12 | -24 | -37 | 0 | -15 | -33 | -52 | 12 | -12 | -38 | -65 |
| .48 | -6 | -18 | -32 | -47 | -7 | -24 | -43 | -65 | 4 | -23 | -51 | -81 |
| .50 | -11 | -25 | -40 | -56 | -13 | -33 | -54 | -78 | -3 | -33 | -64 | -96 |
| .52 | -15 | -31 | -48 | -66 | -20 | -42 | -65 | -91 | -11 | -43 | -76 | -111 |
| .54 | -20 | -38 | -56 | -75 | -26 | -50 | -76 | -104 | -19 | -53 | -89 | -126 |
| .56 | -25 | -44 | -64 | -85 | -33 | -59 | -87 | -117 | -27 | -64 | -102 | -141 |
| .58 | -30 | -50 | -72 | -94 | -40 | -68 | -98 | -130 | -34 | -74 | -115 | -156 |
| .60 | -35 | -57 | -80 | -104 | -46 | -76 | -108 | -143 | -42 | -84 | -127 | -171 |
| .62 | -40 | -63 | -88 | -114 | -53 | -85 | -119 | -156 | -50 | -94 | -140 | -186 |
| .64 | -45 | -70 | -96 | -123 | -59 | -94 | -130 | -169 | -57 | -104 | -153 | -201 |
| .66 | -50 | -76 | -104 | -133 | -66 | -103 | -141 | -182 | -65 | -115 | -165 | -216 |
| .68 | -54 | -83 | -112 | -143 | -73 | -111 | -152 | -195 | -73 | -125 | -178 | -231 |
| .70 | -59 | -89 | -120 | -152 | -79 | -120 | -162 | -208 | -80 | -135 | -191 | -247 |
| .72 | -64 | -96 | -128 | -162 | -86 | -129 | -173 | -221 | -88 | -145 | -203 | -262 |
| .74 | -69 | -102 | -136 | -171 | -92 | -137 | -184 | -234 | -96 | -155 | -216 | -277 |
| .76 | -74 | -108 | -144 | -181 | -99 | -146 | -195 | -247 | -103 | -165 | -229 | -292 |
| .78 | -78 | -115 | -152 | -191 | -105 | -154 | -205 | -260 | -111 | -176 | -242 | -307 |
| .80 | -83 | -121 | -160 | -200 | -112 | -163 | -216 | -273 | -119 | -186 | -254 | -321 |

TABLE NO. 53-V

AIR LEAKAGE CONTROL W/HEAT RECOVERY VENTILATION POINTS

| Air Leakage Control* | Zone 1 | Zone 2 | Zone 3 |
|---|---|---|---|
| Standard | 0 | 0 | 0 |
| Advanced | 59 | 76 | 87 |

* See Section 5305(b)4.

THE FOLLOWING STANDARDS SHOULD BE ADDED TO CHAPTER 60.

1987 NWEC

# NORTHWEST ENERGY CODE STANDARD NO. 25

## Ventilation System Installation Standards

## 1.0 SCOPE

These specifications established the minimum ventilation system requirements for design and installation. R-3 occupancies complying with the provisions of standard air leakage control (Section 5305(b)4C) shall comply with the provisions of Section 3.0 as a minimum or may also comply with the provisions of Section 4.0 or Section 5.0. Buildings complying with the provisions of advanced air leakage control (Section 5305(b)4D) shall comply with the provisions of Section 4.0 or Section 5.0 only.

## 2.0 DEFINITIONS

- **AAHX:** Abbreviation for an air-to-air heat exchanger.

- **AAHX System:** All components associated with the AAHX installation.

- **Air, Exhaust:** The air stream flowing from the mechanical ventilation device to the atmosphere, consisting of stale indoor air; air removed from a space and not reused therein.

- **Air, Flow distribution:** The distribution of air within the conditioned space.

- **Air, Indoor:** Air contained inside conditioned space.

- **Air, Intake:** The air stream passing from the exterior of the house to the mechanical ventilation device, consisting of outdoor air.

- **Air Makeup:** Outside air supplied to replace exhaust air.

- **Air, Outdoor:** Air taken from the external atmosphere and, therefore, not previously circulated through the system.

- **Air, Return:** The air stream passing from the mechanical ventilation device to conditioned space, consisting of outdoor air.

- **Air, Supply:** The air stream passing from the mechanical ventilation device to conditioned space, consisting of outdoor air.

- **Air, Tempered:** Air taken from the external atmosphere that has been warmed.

- **Balanced System (whole-house):** Balanced means a ventilation system in which the flow rate of the exhaust air leaving the building is equal to the supply airflow rate entering the building, as measured at the AAHX within ±20 percent using balancing equipment and procedures specified by a certified AAHX system designer or manufacturer's testing equipment.

- **Calibrated Flow Measurement Devices:** Devices which provide for measurement of mass flow performed in accordance with the Air Movement and Control Association's Standard 210.

- **Central System:** System designed to deliver and to exhaust air, in a distribution throughout the house, and connected to a central air movement system.

- **Cold Side:** The air streams going to and from the outdoors, to and from the mechanical ventilation device.

- **Combined Living Areas:** Rooms with one half of the area of the common walls open and unobstructed and provides an opening of not less than one tenth of the floor area of the interior room or 25 square feet, whichever is greater.

- **Damper:** A device used to vary the volume of air passing through an air outlet, inlet, or duct.

- **Diffuser:** A terminal device designed to supply air to the conditioned space.

- **Exchanger, Air-to-Air Heat (AAHX):** A device in which heat is transferred between two air streams.

- **Exhaust Air Heat Pump (EAHP):** A heat pump system that is designed and used to ventilate the interior envelope of a building and provide a reintroduction of energy in the form of potable hot water or potable hot water and space heating.

- **Flow Balanced System:** A ventilation system designed to avoid an excessive indoor/outdoor pressure differential by incorporating both supply and exhaust fans which can be adjusted for flow balancing.

- **Flow Rate:** The rate of air flow expressed in cubic feet per minute.

- **Flow System Unbalanced:** A ventilation system in which the flow rates of the exhaust air leaving the building are not equal to the supply air entering the building. This type of system produces a negative building pressure in which the interior air pressure is less then the exterior air pressure.

- **Free Area:** Unobstructed area for airflow through a grill, register, or hood.

- **Grille:** An air terminal device used to supply or remove air from a conditioned space.

- **Hard Wire:** Wired directly from the electrical junction box without the use of a plug or receptacle.

- **Habitable Room:** A space or room designed for human occupancy, such as a bedroom, living room, dining room, kitchen, family room, recreation room, or den.

- **Hoods:** Exterior wall terminals for the air intake and the exhaust air flows.

- **NWEC:** The Northwest Energy Code promulgated by BPA.

- **Pressure Balanced System:** A ventilation system designed to avoid excessive indoor negative pressure by incorporating one or more passive air inlets in conjunction with exhaust fans.

- **Pressure Drop:** Static pressure loss in fluid pressure (as from one end of a duct to the other, due to friction, dynamic losses, and changes in velocity pressure).

- **Readily Accessible:** Available to the average person in order to maintain, and be accessible without the use of tools or ladders.

- **Registers:** An air terminal device with a built-in damper.

- **Sone:** The sone is equal in loudness to a pure tone of 1,000 cycles per second at 40 decibels above the listener's threshold of hearing.

- **Supply:** See air, supply.

- **Ventilation:** The process of supplying and removing air by natural or mechanical means to and from any space. Such air may or may not be conditioned.

- **Ventilation, Continuous:** A continuous supply of outside air at the specified minimum rate achieved at least 23 hours per day.

- **Ventilation, Net:** The total supply airflow adjusted by the amount of cross leakage to determine the net fresh air supply.

- **Ventilation Rate (VR):** The total volume of air introduced into a conditioned space per unit time. (Specifically: cubic feet per minute (CFM).

- **Warm Side:** The air streams going to and from the conditioned space, to and from the mechanical ventilation device.

## 3.0 NON-HEAT RECOVERY MECHANICAL VENTILATION SYSTEMS

3.1 **Scope.** This section applies to the design and installation of non-heat recovery ventilation systems for individual dwelling units that are capable of providing a minimum rate of ventilation air to the whole-house and an increased ventilation rate, on an intermittent basis, for exhausting indoor contaminants in kitchens and bathrooms (spot ventilation), when required. Buildings using advanced air leakage control may not use non-heat recovery ventilation.

3.2 There are four design methods for achieving whole-house and spot ventilation capacity:

a. **Integrated Spot and Whole House Design:** This system uses one or more of local ventilation fans to provide whole house ventilation. Fresh air inlets in bedrooms and undercut doors shall provide the air circulation of fresh air through the house to the localized fan.

b. **Ducted Central Exhaust Design:** This system uses a single large multi-speed exhaust fan ducted to bedrooms, baths, kitchen and living areas to provide both whole-house and spot ventilation. The fan is controlled to provide a high speed, high flow exhaust when needed for spot ventilation in the kitchen or bathrooms. The fan also operates at a lower flow rate when controlled to provide whole house ventilation.

c. **Discrete Spot and Whole-House Design:** This system uses separate fans and control systems to provide spot and whole house ventilation.

d. **Forced Air Heating/Cooling System Integrated Design:** In this system spot ventilation is provided through bath and kitchen exhaust fans but whole house ventilation and make up air are provided through integration with the forced air heating/cooling system.

3.3 **Design and Installation Requirements:**

a. **System Sizing:** A mechanical ventilation system shall be sized to provide the quantities of exhaust ventilation specified in section 5305(b)1H.

b. **Whole House Fan Ratings:** Fans used to provide whole house ventilation shall be rated for noise and airflow as follows:

1. **Noise:** All fans used to provide whole-house ventilation shall have a tested sone rating of 2.5 or less. The noise rating shall be tested at the rated capacity operated at 0.1 inches of static pressure. This rating may be exceeded if the fan is remotely located from the space being ventilated.

2. **Airflow:** The fan capacity shall be rated output at 0.1 inches of static pressure.

c. **Backdraft Dampers:** A tight-fitting backdraft damper shall be provide in each exhaust duct and capable of closing when the fan is not in use.

d. **Ductwork:** Ductwork connected to the whole house fan shall be installed with minimum bends and shall be of minimum size per the following table:

| AIRFLOW (CFM) | DIAMETER (inches) |
|---|---|
| less than or equal to 50 | 3.5 |
| from 50 to 100 | 5 |
| more than 100 | 6 |

In climate zones 2 and 3, provisions shall be made to deal with condensation and frost build-up in ducts located outside the conditioned space.

e. **Controls:** Each ventilation system shall have controls for both the spot ventilation fans and the whole house fans that meet the following requirements:

1. Spot ventilation in baths shall be controlled by crank timers, dehumidistats, light switches, or as approved. Spot ventilation in kitchens should be controlled by dehumidistat or crank timers but may be controlled by a manual switch.

2. The whole house fan shall be controlled to operate on an automatic basis and to allow manual operation if desired. The automatic control system shall be based upon humidity levels (dehumidistat) or time (time of day timers or cycle timers) or as approved. The whole house fan shall also be connected to a manual override switch that allows the occupant to turn the fan on continuously or to disable the system if desired.

f. **Makeup Air:**

1. **General:** The minimum makeup air to be provided shall be equal to the number of sleeping room times 10 cfm plus an additional 10 cfm.

The makeup air requirement may be provided by fresh air ports. Flow controlled ports designed to provide fresh air installed in each room requiring make up air: or, central makeup air ducts: A central duct providing makeup air directly to the return plenum of a forced air heating/cooling system and a circulating fan circulates the fresh air to the required rooms (used with Forced Air Heating/Cooling System Integrated Design).

2. **Source:** The source for fresh air makeup shall be located to minimize the potential to draw outdoor air pollutants inside during whole house fan operation. The source shall also be located to minimize the potential for excessive outdoor noise levels being transmitted to the interior through the makeup air system.

3. **Protection:** The source for makeup air shall have adequate provisions on the exterior connection to protect the system against entry by insects, birds, leave, or other such objects.

4. **Mixing/Tempering:** Provisions shall be made to temper the make up air before it is allowed to enter the occupied zone. This may be achieved by drawing makeup air in through long thin slots to mix with room air, direct heating, drawing through a buffered space, or as approved.

5. **Flow Control:** The makeup air source shall have provisions for flow control to limit excessive air flows under normal operation.

6. **Distribution:** Adequate provisions to ensure distribution of the makeup air to the necessary rooms and to the appropriate whole house fans shall be made such as undercut doors, ducted exhaust ports, exhaust air plenums, etc.

3.4 **Operation Check:** The following items will be verified by the system installer.

a. Exhaust airflow and Makeup airflow.
b. Controls are provided and verified to operate according to approved design.
c. Equipment Identification.
d. Operation and maintenance are available at ----------------.

## 4.0 AIR-TO-AIR HEAT EXCHANGERS

4.1 **Scope:** This specification applies to the design and installation of air-to-air heat exchange systems capable of meeting ventilation requirements of Section 5305(b)1H while providing heat recovery. Spot ventilation requirements for baths and kitchens may be met through the Air to Air Heat Exchanger or by separate exhaust fans.

4.2 **System Design and Installation:**

a. **General:** The AAHX shall be specifically designed for use in residential buildings, and shall be capable of ventilating the conditioned space by introducing outdoor air and exhausting indoor air. The outdoor air shall be conditioned through an exchange of heat from the indoor air that is being exhausted to the outside of the building.

The overall ventilation rate of any dwelling unit using mechanical ventilation capacity and natural air leakage shall be a minimum of 0.35 air changes per hour (ACH). Buildings complying with the provisions of Advanced Air Leakage Control shall be sized based on the assumption that the natural air leakage rate for dwellings is 0.1 ACH for the purpose of calculating the mechanical ventilation capacity.

b. **System Design:**

1. **General:** Systems shall be sized and designed to provide the design air change rate to the conditioned spaces at the registers according to one of the following methods:

**Prescriptive Method:** The system shall be sized according to the provisions of Section 4.2(c) Prescriptive Sizing Method, or,

**System Design Method:** The entire system shall be designed and sized for each house submitted using the calculated pressure loss or the equivalent length method by an approved designer. The system design shall include complete duct friction loss calculations, AAHX unit fan pressure/flow curves, register and grill pressure drops. Documentation including all of the above information shall be available for review upon request.

2. **Delivered Capacity:** As an overall system, including all ductwork and registers, the AAHX system shall be designed to be capable of providing a minimum installed mechanical ventilation capacity of 0.25 ACH to the conditioned space when run continuously. The maximum installed capacity shall be 0.35 ACH when run continuously. AAHX systems using inline duct heaters to provide space conditioning may exceed the 0.35 ACH capacity limit.

The AAHX system may exceed 0.35 ACH in capability if the system is being used for bath and kitchen exhaust ventilation requirements set forth elsewhere. However, the system shall only exceed the maximum delivered capacity for purposes of exhausting these spaces.

3. **Type:** The AAHX system shall at a minimum be a BPA approved central system type. It shall also comply with the uniform building and uniform mechanical codes.

4. **Supplies:** There shall be an air supply to each bedroom and one additional habitable conditioned space.

5. **Returns:** There shall be, at least, one return within the conditioned space. If there are no exhaust fans in the kitchen, bathroom, or utility areas, then there shall be one return located in each of those spaces, allowing the AAHX to serve as the exhaust system.

6. **Sound Attenuation:** Vibration arrestors shall be installed per manufacturer's recommendations. Flex duct shall be included between the unit and the supply duct. Acoustical isolation shall be provided between adjacent rooms

c. **Prescriptive Sizing Method:** This section provides a method for sizing central system AAHXs and the associated ductwork for a minimum installed capacity without performing detailed calculations on each system.

If the system does not conform to all of the provisions of this section, then it must be designed according to the Complete System Design Method in Section 4.2(b).

System Requirements: All of the following conditions will be satisfied for each AAHX before the system and ductwork can be sized.

1. **Floor Area:** Each unit shall comply with the requirements of Table 4-1. It shall not handle a floor area in excess of 3000 sq ft.

2. **Balancing:** The stale air and fresh airflow streams include balancing dampers to allow for balancing within 10 percent.

3. **Exhaust Branch Duct Runs:** A minimum of one and a maximum of four stale air exhaust branch duct runs are included in the system.

4. **Supply Branch Duct Runs:** A minimum of three and a maximum of five fresh air supply branch duct runs are included in the system.

5. **Straight Duct Run Length:** A maximum duct run length of 100 feet of straight duct from the outside hoods to any of the inside registers.

6. **Main Branch Elbows:** A maximum of six 90 degree elbows or bends or twelve 45 degree elbows or bends from the outside intake or exhaust hood to the main duct run between the AAHX and the first branch for either the fresh or stale air duct runs.

7. **Branch Duct Elbows:** A maximum of six 90 degree elbows or bends or twelve 45 degree elbows or bends from the first branch off the main duct run to any register for either the fresh or stale air duct runs.

8. **AAHX Minimum Design Flow Rate:** The AAHX from the approved list shall be capable of providing the design flow rate of 0.25 ACH at 0.3 inches of water equivalent external pressure drop.

**Table 25-1**

**Design Flow Rate and Duct Size by Conditioned Floor Area**

| **Conditioned Floor Area** | **Design Flow Rate** | **Minimum Duct Size** | |
|---|---|---|---|
| **(square feet)** | **(cfm)** | **Flex (in)** | **Smooth (in)** |
| 200 | 7 | 3 | 2 |
| 400 | 13 | 4 | 3 |
| 600 | 20 | 4 | 3 |
| 800 | 27 | 5 | 4 |
| 1000 | 33 | 5 | 4 |
| 1250 | 42 | 5 | 4 |
| 1500 | 50 | 5 | 4 |
| 1750 | 58 | 6 | 5 |
| 2000 | 67 | 6 | 5 |
| 2250 | 75 | 6 | 5 |
| 2500 | 83 | 7 | 6 |
| 2750 | 92 | 7 | 6 |
| 3000 | 100 | 7 | 6 |

d. **Unit Location:** The AAHX unit shall be located in a conditioned space, or as approved. The AAHX unit shall be located and installed in such a manner so that controls, filters, exchanger cores, condensate removal equipment and wiring are all readily accessible for routine maintenance and removal. The AAHX shall be located and installed to minimize noise.

**e. System Control Strategy:**

1. **General:** Control system design and installation shall comply with all local electrical codes and be capable of operating the unit continuously. all controls shall be labeled as to function and operation.

2. **Power:** A separate power circuit shall be provided for the AAHX and the unit which shall be hard wired to that circuit if the listing so states.

3. **Dehumidistat:** There shall be a dehumidistat in the system located in the general living area away from the major humidity sources. The dehumidistat shall increase the ventilation rate when activated,
and shall be adjustable from 30 percent to 80 percent relative humidity ± percent.

4. **On/Off Switch:** A listed on/off switch shall be installed and accessible to the occupant. The switch shall be clearly marked to indicate its "on" position. The on/off switch shall be located next to the dehumidistat sensing device and control. If multiple switches are used to control the unit, each switch shall independently control the unit without interfering with any other switches.

5. **Variable Speed Control:** Variable speed operation or high/low speed setting shall be provided for the AAHXs that are being used to meet the exhaust requirements for baths and/or kitchens, but is not necessary on the AAHX unit that is specifically designed to run in a constant "on" mode and which has the capability to provide 0.35 ACH (including basements).

**f. Ducts and Distribution System:**

1. Ducts shall be located within the enclosed areas of the dwelling.

2. Ducts shall not be located in exterior wall cavities.

**EXCEPTION:** Ducts may be located in exterior wall cavities if a minimum of 2-inch exterior rigid foam plastic insulation can be placed between the duct and the outside wall surface.

3. Warm side ducts that are located in unconditioned spaces shall be insulated to not less than R-4.

4. Cold side intake and exhaust ducts leading from the unit shall have an exterior vapor barrier plus a minimum of R-4 insulation. Return ducts in unconditioned spaces as well as exhaust ducts shall have interior vapor barriers.

5. Uninsulated ductwork shall not be buried in the attic or floor insulation.

**EXCEPTION:** Uninsulated duct runs located in attics or floors may be insulated by covering the duct with an equivalent level of insulation as required for the floor/ceiling or roof/ceiling provided that the duct is located either in the joist cavities or is resting directly on the joists. Ducts stacked on other ducts shall not be allowed to be insulated by floor/ceiling insulation.

6. Ducts shall be designed and installed to minimize pressure drop. Duct runs shall be installed with minimum change in direction and a minimum length of material.

7. Ductwork shall be supported adequately to prevent unnecessary bends and sags. Strapping and support of ductwork shall be installed as per the Uniform Mechanical Code and manufacturer's specifications. Use of duct tape or similar materials for support and strapping shall not be permitted.

8. All ducts shall have a minimum nominal interior diameter as determined by the prescriptive sizing requirements or as determined by the system design.

9. If prescriptive sizing requirements are used, air intake grilles shall have a minimum free area of 36 square inches for each 100 CFM of design airflow at the air intake. Air outlet grilles shall have a minimum free area of 30 square inches for each 100 CFM of design airflow at the exhaust hood.

10. For AAHX's without preheated supply air, all supply diffusers installed in frequently occupied rooms shall be designed for air-conditioning use, shall be ceiling outlets or high-wall diffusers, and shall be installed in accordance with manufacturer's recommendations. Supply diffusers installed in rarely

occupied and less thermally sensitive areas may use air distribution systems that minimize air velocity to reduce drafts in lieu of air-conditioning design.

11. Adjustable, tamper-proof registers shall be provided.

12. Balancing dampers shall be installed on the warm side of the unit on both air streams, within 2 feet of the unit, or an approved alternative that assures incoming/outgoing flows are within 10 percent of each other. Air distribution adjustment from room-to-room may require additional balancing dampers. If the AAHX unit is capable of running in an unbalanced mode for defrost purposes with an imbalance of no more than 50 percent more airflow in the exhaust stream than in the intake air stream.

13. Outside intake and exhaust shall be located at least 6 feet from each other, and shall not be located by driveways, carports, or areas where contaminated air is likely to exist. All hoods shall be a minimum of 12 inches above finished grade and should be protected from environmental degradation. Intake and exhaust hoods shall incorporate 1/4-inch mesh screen or the equivalent. Intake hoods shall be located at least 6 feet away from clothes dryers, kitchen and bathroom exhaust fan hoods, and shall not be located on roofs. The outside hood shall have a backdraft damper.

g. **Condensate:**

1. Condensate removal piping and equipment shall be designed and installed according to the manufacturer's specifications.

2. Condensate removal piping equipment design and installation shall comply with all applicable State and local codes.

3. The condensate lines shall be installed in a space where the temperature is maintained above the freezing point.

h. **Filters:**

1. The AAHX shall have a particulate filter located on the return duct upstream from the AAHX which is adequate to prevent contamination of the AAHX core from general

airborne dust.

2. The AAHX shall also have a filter sufficient to remove the majority of pollens and other aeroallergens, and be located on the intake stream to the AAHX. The intake air filter shall be readily accessible for maintenance.

3. Filters shall be installed in accordance with the manufacturer's instructions.

4. One set of clean air filters shall be left with the unit for replacement by the occupants.

4.3 **Duct Heaters:** All heating devices used to condition airflows in the AAHX system including duct heaters or terminal reheaters shall comply with the provisions of this Section.

a. **Local Codes:** The installation shall comply with all local building, electrical and mechanical codes.

b. **Unit Listing:** The duct heater shall be UL listed, CSA approved, or have an approved equivalent safety certification.

c. **Ducts:** Sheet metal or approved ducting shall be used for a minimum of 5 feet downstream and 1-foot upstream of the duct heating unit.

d. **Airflow Capacity:** Airflow capacity of the AAHX shall meet the following requirements:

1. Match duct heater specifications,
2. Not allow duct temperature rises which exceed 67 degrees F, and
3. Be able to maintain suitable duct temperatures for occupant comfort.

e. **Airflow Distribution:** Provisions shall be made to assure even airflow across heater elements.

f. **Duct Heater Size:** The duct heater shall have a thermal output capacity of no greater than 125 percent of the whole-house design heating load.

g. **Controls:** A feedback sensing control and/or a manual override on/off switch shall be provided that prevents the house from overheating and/or prevents entry of cold air supply.

h. **Labels:** There shall be instructional labels on all controls.

i. **Accessibility:** The duct heater shall be easily accessible for repair or replacement.

j. **System Design:** If a non-packaged system is used, then a registered professional engineer shall approve the system design.

k. **Manuals:** Duct heater systems shall be accompanied by an installation manual and a homeowner manual describing the operation of the heater in conjunction with the AAHX and the operation of all controls and safety features.

4.4 **Forced Air Furnace Integration:** systems designed and installed to use the forced air heating system ducting for distribution of supply air shall comply with the provisions of this section.

a. **Exhaust Ducts:** A separate stale air exhaust duct system shall be installed to the AAHX according to the provisions of Section 5.2 System Layout.

b. **Supply Duct:** The AAHX fresh air supply shall be ducted to within 12 inches of an undampered return grille of the forced air heating system. the supply duct shall not be directly connected to the undampered return grille of the forced air heating system.

**EXCEPTION:** Direct connection may be allowed if specified as a recommended installation by the manufacturer and as approved by the participating utility.

c. **Forced air Return Grille Size:** The area of the return air grille where the AAHX supply air is ducted to shall be at least 150 percent of the area of the AAHX fresh air supply duct.

d. **Location:** The AAHX and the opening in the return grille shall be located in a conditioned space.

e. **Fan Control:** The forced air heating system fan control shall allow for two-speed operation including a low speed for continuous fresh air distribution as well as the normal high speed for heating. The low speed setting shall be designed for continuous operation without affecting occupant comfort.

f. **Flow Control:** Dampers shall be provided to allow a flow balanced system.

4.5 **Operation Check:**

a. **System Operation:**

1. The installer shall certify that the AAHX system operates as designed. The actual flow delivered to the conditioned space shall meet the design flow within 10 percent.

2. All control devices shall function as intended.

b. **System Balancing:**

1. the installer shall balance the system by measuring total volumetric airflow in both flow paths using calibrated flow measuring device and by adjusting balancing dampers and/or supply register dampers to obtain equal flow rates (± 10 percent) in both the supply and exhaust airflow paths.

2. a means of balancing airflow in branch ducts shall be provided where necessary.

c. **Airflow Measurement:** the airflow rates into the house from each supply register shall be measured and adjusted, if possible, to provide an even ventilation pattern throughout the house.

d. **Wiring:** All of the control wiring and power wiring connections shall be thoroughly checked out at startup.

e. **Controls:** The installer shall provide the homeowner with a description of the control setup for the AAHX system. The description shall explain the various control devices and indicate an initial setpoint. It shall also describe the purpose behind each control and suggest methods for adjusting setpoints to obtain an acceptable ventilation rate.

f. **Manufacturer Information:**

1. the installer shall provide the homeowner with a complete set of the manufacturer-supplied information which accompanied the AAHX.

2. The installer shall affix all manufacturer-supplied caution, maintenance, operation, etc., labels to the proper

location on the system.

3. The installer shall provide the homeowner with a written manufacturer's warranty.

4. the installer shall provide the homeowner with the name, address and phone number of the nearest manufacturer's representative, and/or the nearest equipment service center.

g. **Labeling:**

1. The four ducts attached to the AAHX shall be labeled as to the function.
2. All controls shall be labeled.

h. **Certification:**

1. the installer shall certify completion of the installation and correct airflow/balancing adjustments by completing a form approved by BPA.

2. The installer shall certify that a complete set of manuals providing clear instructions and sizing information for installation and operation for the householder to perform routine maintenance was provided.

3. The installer and recipient shall sign the form. A copy shall be provided to the homeowner/builder and the manufacturer of the AAHX.

## 5.0 EXHAUST AIR HEAT PUMP (EAHP) VENTILATION SYSTEM

5.1 **Scope:** This specification applies to the design and installation of exhaust air heat pump systems for individual dwelling units. Buildings complying with the provisions of advanced air leakage control shall comply with all of the provisions of this chapter or Section 4.0 Air-to-Air heat Exchangers. Spot ventilation requirements for baths and kitchens may be met through the exhaust air heat pump system or through separate exhaust fans.

5.2 **Design and Installation Requirements:**

a. **System Design:** the exhaust air heat pump system shall be specifically designed for use in residential buildings and shall be capable of ventilating the conditioned space by extracting air from indoors and providing for the introduction of outdoor air.

The primary function of the EAHP system will be to provide ventilation inside a closed building by extracting interior air and running it through a properly sized heat pump to reclaim the exhausted heat energy in the form of potable hot water.

A properly sized heat pump is a unit that is designed to maintain the minimum ventilation rate as required and is capable of supplying all of the domestic hot water needs.

Secondary space heating is an option that may be used in conjunction with the water heater. If the space heating option is to be used, the electrical resistance element in the hot water heater shall be disabled during the space heating mode.

b. **Ventilation Rate:** The control system shall be designed to be capable of maintaining the minimum ventilation rate required.

c. **Resistance Backup:** A resistance backup coil shall be provided and shall be sized to be capable of supplying the hot water demand load when the heat pump ventilation system is not in operation.

d. **Location:** The EAHP system shall be located in a readily accessible conditioned space, acoustically isolated, and protected against freezing. Ease of maintenance and service shall be a major consideration when locating the heat pump unit. The system shall be placed in such a location as to optimize operating efficiency and that duct runs from the EAHP are as short as possible, minimizing bends and restrictions, and in facilitating placement of supply and return points.

e. **Supply and Return Points:** The EAHP system shall be designed in such a manner as to provide whole-house ventilation and heat recovery. At a minimum, supply shall be provided to each bedroom and one general living area. There shall be at least one centrally located return point. If separate exhaust fans are not installed in baths and kitchens, the EAHP shall provide a return in each bath and kitchen. Returns in kitchens shall not be placed over ranges.

f. **Interior Vents:** All air supply and return points within the house shall be covered with register/grilles and shall be located to reduce the possibility of airflow short circuit between the supply/return lines. air supply registers shall be located in the ceiling or high on wall surfaces to provide maximum supply of airflow with minimum discomfort and shall direct the airflow parallel to the floor/ceiling surfaces or upward toward the ceiling. Return grilles shall have flow control dampers.

g. **Exterior Vents:**

1. **Hoods:** Intake and exhaust hoods shall be at least 12 inches above the finish grade. The air intake inlets are recommended to be located on the south side of the building but not to be located by a driveway or carport. Hoods shall be resistant to environmental degradation and shall be labeled as to their proper function (e.g., 'exhaust air'). Other locations may be accepted as approved.

2. **Outside Vents:** The outside air intake vents shall be separated from the outside exhaust vents by at least 6 feet unless properly designed intake and exhaust nozzles allow back-to-back placement with no possible crossflow contamination.

3. **Backdraft Damper:** A backdraft damper shall be installed in the outside exhaust hood. both intake and exhaust hoods shall be turned downward to prevent rain and snow entry and located where ice formation will not cause safety problems.

h. **Duct Layout and Design:** Ducts shall be sized and designed according to standard engineering practice. Duct installation shall meet all State and local building codes for safety and construction. ducting shall have duct joints and seams sealed with tape or similar means. Ductwork from the heat pump to the outside exhaust shall be installed to provide adequate drainage of condensation.

i. Duct Insulation shall comply with the requirements of Section 4.2(e).

j. **Filters:** filters shall be installed upstream of the exhaust air heat pump equipment in both the intake and return airducts and insect screens shall be installed at all outside intake and exhaust points.

k. **Condensation:** A condensation drain shall be provided for the heat pump so that any possible overflow of moisture will be piped to a suitable drain and all building codes are met.

Any piping used for condensate control shall be within a conditioned space and shall direct condensate to a non-freezing drain.

5.3 **Operation Check:**

a. **Certification:** The equipment shall be certified in accordance with the Gas Appliance manufacturer's Association approved equivalent.

b. **Warranty:** The heat pump unit shall be provided with a 1-year written warranty on parts, a homeowner manual, and installation instructions.

c. **Installer Verification:** The system installer shall verify that the system operates as designed. the installer shall complete a form containing the following items: Verification of Airflow, Controls, Equipment Identification, Brochures and Operation and Maintenance.

**References:** The following documents are not all specifically referenced in this specification but are listed to provide additional sources of information regarding ventilation system design and installation.


- Underwriters Laboratory Inc., Standard (ULI)
  181-1987 - Factory-made Airducts and Connectors
  883 - Fan Coil Units and Room-Fan Heater Units.
  507 - Electric Fans.

- Uniform Mechanical Code 1985

- National Electric Code 1985

- Uniform building Code 1985

- Canadian Standards Association (CSA) Preliminary Standard C439-M1985 Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators

- Canadian Standards Association (CSA) C444 -M1985 Installation Guidelines for Heat Recovery Ventilators

- Canadian Standards Association (CSA) C22.2 No. 113-M1984 Fans and Ventilators

- American Society of Heating, Refrigeration and Airconditioning Engineers (ASHRAE) Standard 62-81, Ventilation for Acceptable Indoor Air Quality

- American Society of Heating, Refrigeration and airconditioning Engineers (ASHRAE) Standard 62-81, Ventilation for Acceptable Indoor Air Quality

- Home Ventilating Institute, Division of AMCA, Heat Recovery Ventilator's Product Certification Procedure, Heat Recovery Ventilator's Performance Test Standard for Ducted Heat Recovery Ventilators

- Air Movement and Control Association (AMCA) 210 Laboratory Methods of Testing Fans for Rating.

- Bonneville Power Administration: Air to Air Heat Exchanger Product Specifications (NWEC Standard #26)

# NORTHWEST ENERGY CODE STANDARD NO. 26

## Bonneville Power Administration
## Air-to-Air Heat Exchangers
## Product Specifications

### 1.0 SCOPE

This specification covers self-contained central air-to air heat exchangers made of factory-assembled components in which heat is transferred between two isolated airstreams.

### 2.0 PURPOSE

The purpose of this specification is to establish minimum material and performance requirements for central air-to air heat exchangers. This specification establishes minimum acceptable levels of performance based on the test procedure in Section 7.0.

### 3.0 DEFINITIONS

For the purpose of this specification, the following terms are defined:

- **Air-to-Air Heat Exchanger (AAHX):** A device used to ventilate the conditioned space by exhausting indoor air and supplying fresh air and which transfers heat between two isolated airstreams.

- **Bonneville:** Bonneville Power Administration.

- **Manufacturer:** Person or persons which assemble the elements or components of the air-to-air heat exchanger.

- **MCS Programs:** Model Conservation Standard support programs.

- **Net Ventilation:** The volume of air introduced into the conditioned space per unit time.

### 4.0 REFERENCES

Referenced standards are as follows:

Heat Recovery Ventilator Performance Testing Standard for Ducted Heat Recovery Ventilators, Home Ventilating Institute (HVI), 1987 edition.

## 5.0 GENERAL REQUIREMENTS

5.1 These specifications are intended to comply with applicable existing codes and Federal regulations. In any case where a Federal, State or local code or regulation exceeds the requirements herein, that code or regulation shall apply.

5.2 Air-to-air heat exchangers installed under MCS Programs shall meet the criteria defined in this specification. The Manufacturer shall be responsible for submitting to Bonneville or its designated representative the test information for evaluation prior to installation. Once accepted under MCS Programs, the product shall be approved without resubmittal to Bonneville except as noted in Paragraph 5.3. The unit shall also be proven to comply with uniform building and uniform mechanical code requirements.

5.3 Bonneville reserves the right to identify and disapprove for use in MCS Programs, any product at any time when it is deemed the product is not satisfactory for future use in MCS Programs. Such disapproval shall be issued in writing and shall identify the flaws found in the product. Disapproval shall be issued after consultation with the manufacturer.

## 6.0 PRODUCT REQUIREMENTS

6.1 The air-to-air heat exchangers supplied shall be specifically designed for use in residential buildings. The unit shall be rated for voltage which is nominally available in a single family residence. Power shall be supplied to the unit through Underwriter Laboratories' (UL) or Canadian Standards Associations' (CSA) or approved equal listed three conductor wire (one conductor is ground) either permanently wired or through the use of UL listed electrical cord and a three-prong plug.

6.2 The motor(s) shall be matched to the blower(s) and the conditions under which the blower(s) operates. The motor(s) shall be listed by UL, CSA or approved equal. The motor(s) and blower(s) shall be permanently lubricated.

6.3 The air-to-air heat exchanger including a defrost mode shall be listed by Underwriter Laboratories (UL) or Canadian Standards Association (CSA) or approved equal.

6.4 The components of the air-to-air heat exchanger shall be easily accessible for routine maintenance. The motor(s), blower(s), filter(s), and controls shall be accessible without removing the unit, detaching the ductwork, or using special tools.

6.5 The air-to-air heat exchanger shall have a method of condensate removal that results from the operation of the heat exchanger. This shall be accomplished using a drain system or a comparable mechanism.

## 7.0 TEST REQUIREMENTS

7.1 The air-to-air heat exchanger shall have test data from an approved independent testing agency. Tests shall be conducted in accordance with Heat Recovery Ventilator Performance Testing Standard for Ducted Heat Recovery Ventilators, Home Ventilating Institute (HVI), 1987. For each product to be approved, the above test shall demonstrate compliance with the following criteria:

| Factors | Supply Air Temperature (F) | System Pressure (in W.G.) | Net Air Flow Rate (CFM) | Acceptance Criteria |
|---|---|---|---|---|
| Net Supply Airflow Rate | 32 | 0.2 | | Min 50 CFM |
| Exhaust Air Transfer Ratio | 32 | 0.2 | | Max 0.10 |
| Sensible Recovery Efficiency | 32 | | 50 | Min 0.65 |
| Low Temp. Ventilation Reduction Factor: | | | | |
| Supply | | | | Min 0.85 |
| Exhaust | | | | Min 0.85 |

7.2 The air-to-air heat exchanger shall have tested air flow rates of standard air to within +/- 15% CFM, whichever is greater, of manufacturer's designed flow rates on both supply and exhaust streams.

## 8.0 DOCUMENTATION

8.1 The Manufacturer or his distributor shall provide to the consumer a warranty in writing against manufacturing defects for a period of at least one year. The unit shall be shipped with a written warranty which is understandable to the Consumer.

8.2 The Manufacturer shall provide two Operation and Maintenance instructions with the product, one written for the installer and one written for the consumer. Simple and clear instructions shall include:

1. Range of outdoor temperatures at which the unit is designed to operate,
2. Installation and start-up instructions including options,
3. Recommended operation instructions with air filter description,
4. Routine maintenance instructions with air filter description,
5. Trouble-shooting instructions for minor problems,
6. Component and accessory list, model identification information, and
7. Name, address and telephone number of the Manufacturer or Distributor authorized to service the product.

8.3 The air-to-air heat exchanger shall be identified with the Manufacturer's name and model name or number.

8.4 The source and direction of air flow shall be permanently identified on each of the four duct connections for proper installation and maintenance.

## APPENDIX

The following sections should be placed in the appendix of the UBC.

**Radon Mitigation Specifications**

**Sec. 5309.** (a) **Scope and Definitions.** 1. **Purpose.** The purpose is to establish minimum criteria for the design and installation of radon reduction systems based on monitored radon concentrations in R-3 occupancies which comply with the NWEC. The mitigation requirements will not be required unless a monitoring of the soil around or under the building indicates the presence of radon gas.

2. **Definitions.**

**Isolated Basement.** A basement that is physically separated or capable of being separated from the upper floors of the building. This includes basements with stairwells to upper floors with a closeable door at the upper floor, and penetrations in the basement ceiling which are sealed against air leakage to the upper floors.

**Net Free Ventilation Openings.** The net area of unencumbered vent (i.e., the gross area subtracting the area of screens or louvers) which provides free air access.

**Permeability, Low.** Permeability is considered low when the soil conditions are poorly drained.

**Permeability, High.** Permeability is considered high when the soil conditions are well-drained.

**Pressure Field.** A system of underslab or underground piping which is used to create a pressure gradient underneath the slab.

**Sone.** The sone is equal in loudness to a pure tone of 1,000 cycles per second at 40 decibels above the listener's threshold of hearing.

(b) **General Requirements.** 1. **General.** Residential buildings that do not comply with section 5305(b)16(ii) NWEC shall monitor for the presence of radon gas in accordance with Section 5309(c). Those buildings in which a reading of more than 5 PCi/l shall have a radon reduction system designed, installed and monitored to reduce the concentration to a level of 50% of the initial reading.

> **EXCEPTION:** Buildings complying with the applicable Section 5309(f), 5309(g), or 5309(h) of this chapter.

2. **System Labeling.** A. A label shall be affixed to an accessible permanent, indoor location within each individual dwelling unit.

B. This label shall inform the homeowner that the house contains a radon mitigation system. The label shall state that more information on the system can be obtained by contacting ____ (local utility number) .

(c) **Monitoring for Radon Gas.** 1. **Monitor:** Monitoring shall be performed using a Terradex Corporation type SF passive monitor or an approved equal.

2. **Monitoring Period:** The radon monitor shall be installed within 12 months of completion of the home for a minimum of three

months during the period of September through March or as approved for the monitor being used.

3. **Monitoring Location:** The radon monitor shall be installed on the first story in the main living area of the home on an open shelf or other flat surface, or be suspended from the ceiling 4' to 7' above the floor, away from windows and doors, and away from possible drafts from heating or cooling vents.

4. **Labeling:** The monitor shall be tagged with a label containing information consistent with the Bonneville Power Administration's Residential Weatherization Program specifications for labeling of radon detectors.

5. **Radon Reduction System Requirement Criteria:** After monitoring a radon reduction system shall be installed based upon the monitored radon level and house type as given in Table 9-1.

(d) **Radon Reduction System for Buildings With Basements.** 1. **Application Criteria.** This system shall be used only in buildings with a full or partial basement that can be completely isolated from the remainder of the living space and thus be placed under a constant positive pressure condition relative to the outdoor pressure.

2. **Construction Requirements.** A. **Basement Isolation.** (i) Basements shall be isolated from the living space.

(ii) All holes in the living space floor shall be sealed, including plumbing, electrical, structural supports, etc.

(iii) All duct work penetration through occupied floor over the basement shall be sealed.

(iv) All doors separating the basement from the living area shall be weatherstripped.

B. **Basement Slab Sealing.** Perimeter cracks and control joints shall be caulked.

C. **Basement Wall Sealing.** (i) If the exterior side of the foundation is exposed, the exterior of the foundation shall be damp-proofed and backfilled.

(ii) The top of hollow block walls shall be sealed with ethafoam sill sealer and butyl caulk.

(iii) The interior of block walls shall be coated with epoxy paint or parging.

(iv) All pipes and electrical penetrations shall be sealed with caulk.

D. Ventilation shall be by a stand alone pressurization system or forced air system integration shall be provided.

E. (i) Discrete pressurization system is a permanently installed fan, ducted and controlled to pull air from the upper living areas and exhaust that air into the basement. The fan shall be listed by an agency, designed for continuous operation, and have a sone rating no greater than 2.5.

(ii) The system shall be sized to pressurize the basement by supplying fan ventilation to the basement of a greater capacity than the natural air leakage rate of the basement. As a minimum the quantities listed in table 53-X shall be provided.

F. **Forced Air Heating System in the Section.** This section only applies to basement pressurization systems which are to be integrated with existing forced air heating systems. (i) The forced air heating system shall be a closed-loop system.

(ii) All air for forced air heating system operation shall be provided from the living space return air system.

(iii) A supply air outlet to the basement shall be provided.

(iv) A permanent fan shall be located in the basement supply air outlet to maintain a positive pressure condition relative to the outdoor pressure. It shall be readily accessible for maintenance and replacement.

(v) The fan shall operate independent from the forced air heating system.

(vi) The fan shall have a sone rating of 2.5 or less.

(vii) The size of the fan shall comply with Table 53-X.

(viii) The fan shall be hard-wired to a separate circuit breaker in the main electrical panel.

(e) **Radon Reduction system for Buildings With Slabs-On-Grade.** 1. **Purpose.** To provide a slab-on-grade system that effectively reduces radon entry from the soil beneath the slab by establishing a pressure gradient between the soil and the slab.

2. **Construction Requirements.** A. **Slab Sealing.** Perimeter cracks and control joints shall be caulked.

B. **Slab Holes.** (i) One three foot diameter hole in the slab shall be provided for every 300 to 700 square foot area, depending on the soil permeability.

(ii) If the soil is of high permeability, a slab hole shall be provided for at least every 700 square foot area. If the soil is of low permeability, a slab hole shall be provided for at least every 300 square foot area.

(iii) Each slab hole shall be located at least eight (8) feet in any direction from any other slab hole.

(iv) Each slab hole shall fully penetrate the entire slab depth.

(v) After the hole is made in the concrete, the soil below shall be excavated to the diameter of the slab hole to a depth of 1 foot and filled with gravel to the level of the underside of the slab. A layer of asphalted building paper, 6 mil polyethylene film, or an approved equal shall be placed on top of the gravel fill in the hole to prevent concrete from filling the air spaces in the gravel.

(vi) A 4 inch Schedule 40 PVC pipe long enough to extend 6 inches downward into the gravel and 2 inches upward above the top of the existing slab shall be inserted into the gravel.

(vii) An even coat of epoxy sealant shall then be applied to the walls of each slab hole. A non-shrinking grout and bonding agent mixture shall be poured into the slab hole around the pipe and on top of the building paper to the level of the original slab floor before the epoxy sealant has completely cured.

C. **Piping.** (i) Piping used above the slab shall be four inch outside diameter, Schedule 40 plastic sewer pipe, or approved equivalent.

(ii) A pipe shall vertically penetrate the slab in each slab hole in conformance with section 5309(e)2B(vi) & (vii).

(iii) A finish bead of silicone shall be applied at all pipe/grout joints.

(iv) A piping system shall connect all vertical pipes and be sealed at the joints non-hardening sealant to like pipe sections to form a continuous airflow path to the outside.

D. **Ventilation Fan Requirements.** (i) An approved, listed exhaust fan, designed for continuous operation, with a sone rating of no greater than four, and capable of moving at least 50 CFM of air against 0.5 inches of static water pressure shall be provided within each pipe system.

(ii) The direction of air flow in the slab-on-grade system shall be dependent on soil permeability. If soil is of high permeability, air flow shall be directed from the outdoor air into the slab system, thereby pressurizing the area under the slab. If the soil is of low permeability, air flow shall be directed from the slab system into the outside air.

(iii) All vertical pipes shall be connected and sealed to lie pipe sections to form a continuous air flow path to the outside.

(iv) All pipe sections shall be sealed at the joints with nonhardening sealant.

(v) Fans shall be hard-wired to a separate circuit breaker in the main electrical panel.

(vi) Exhaust fans shall be located on the exterior end of each pipe system in order to facilitate removal for maintenance or replacement, and protected from the environment and inadvertent human contact.

(f) **Radon Reduction system for Buildings With Crawlspaces.** 1. **Purpose.** To provide crawlspace ventilation system that will reduce the concentration of radon in the crawlspace.

2. **Construction Requirements.** A. **Application Criteria.** This system shall be developed only in buildings with a full or partial crawlspace. This mitigation system shall not be installed in homes with crawlspace plenum heating systems.

B. **Crawlspace Isolation.** (i) All penetrations in the living space floor above the crawlspace shall be sealed.

(ii) All ductwork located in the crawlspace shall be sealed.

(iii) All crawlspaces shall be sealed to be isolated from basements, attached garages, or other adjacent enclosed spaces.

C. **Crawlspace Ventilation.** As a minimum, it shall comply with the Uniform Building Code. Baffles shall be installed at foundation vent openings to prevent underfloor insulation from interfering with air flow.

D. **Ventilating Fan Requirements.** (i) Fans shall be listed by an approved agency.

(ii) Fans shall have a sone rating of no greater than four.

(iii) Each fan shall be capable of providing the minimum flow rates as listed in Table 53-Y.

(iv) Fans shall be designed for continuous operation.

E. **Ventilating Fan Installation.** (i) A ventilating fan shall be hard wired into a separate circuit breaker in the main electrical panel.

(ii) Fans shall be oriented in such a way that airflow is drawn from the outside of the crawlspace and delivered into the crawlspace or vice versa. The airflow direction is the choice of the installer/homeowner.

(iii) Where possible, fans shall be located in exterior foundation walls. A large enough crawl space opening shall be provided for maintenance or replacement of the fan.

**TABLE 53-W**
**RADON MITIGATION REQUIREMENTS**

| Radon Reading (pCi/l) | House Type | Requirement |
|---|---|---|
| less than or equal to 5 | Any | No requirement. |
| between 5 and 10 | Any | A whole house central system air to-air heat exchanger meeting the requirements of NWEC Standard No. 25 shall be installed. |
| greater than 10, up to 20 | Full Crawlspace | Passive crawlspace ventilation of 1 sq ft net free ventilating area per 75 sq ft of floor area shall be installed. |
| | Full Isolated Basement | An air-to-air heat exchanger meeting the requirements of NWEC Std 25 and sized for the basement area shall be installed in the basement. |
| | Part Crawl-space, part basement | Passive crawlspace ventilation of 1 square foot of net free ventilating area per 75 square feet of floor area shall be installed in the crawlspace. The house shall then be re-monitored for radon. If the re-monitored level does not exceed 50% of the initial monitored level then no additional action is necessary. If the re-monitored level exceeds 50% then an air to air heat exchanger meeting the requirements of NWEC Standard #25 or a basement pressurization system meeting the requirements of Section 5309(d) or a sub-slab system meeting the requirements of Section 5309(e) shall be installed in the basement. |
| | All Others | Heated Plenum Crawlspaces: If the house has a heated crawlspace used as a heating system plenum then ductwork shall be installed to all |

**TABLE 53-W**
**RADON MITIGATION REQUIREMENTS (CONTINUED)**

| Radon Reading (pCi/l) | House Type | Requirement |
|---|---|---|
| greater than 10 up to 20 | All Others continued | of the floor registers supplied by the crawlspace plenum. Passive crawlspace ventilation of 1 square foot of net free ventilating area per 75 square feet of floor area shall be installed in the crawlspace.<br><br>All other Partial Crawlspaces: Passive crawlspace ventilation of 1 square foot of net free ventilating area per 75 square feet of floor area shall be installed in the crawlspace. The building shall then be remonitored for radon. If the re-monitored levels exceed 50% of the original monitored level then a sub-slab system meeting the requirements of Section 5309(e) shall be installed. |
| infinity | Full Crawlspace | An active crawlspace ventilation system shall be installed. |
| | Full Basement isolatable | A slab on grade system complying with Section 5309(e) shall be installed. |
| | Part Crawlspace, part Basement | An active crawlspace ventilation system meeting the requirement of section 5309(f) shall be installed and the house shall be remonitored for radon. If the re-monitored results are less than or equal to 50% of the initial monitored level, then a basement pressurization system meeting the requirements of Section 5309(d) or a slab on grade system meeting the requirements of Section 5309(e) shall be installed. |
| | All Others | Heated Plenum Crawlspaces: If the house has a heated crawlspace used |

TABLE 53-W
RADON MITIGATION REQUIREMENTS (CONTINUED)

| Radon Reading (pCi/1) | House Type | Requirement |
|---|---|---|
| | All Others continued | as a heating system plenum then ductwork shall be installed to all of the floor registers supplied by the crawlspace plenum. A crawl-space ventilation system meeting the requirements of Section 5309(f) shall then be installed.<br><br>All Other Partial Crawlspaces: An crawlspace ventilation system meeting the requirements of section 5309(f) shall be installed. The building shall then be remonitored for radon. If the remonitored levels exceed 50% of the original monitored level then a sub slab system meeting the requirements of section 5309(e) shall be installed.<br><br>All other Slab Floors Without Crawlspaces: shall have a slab on grade system meeting the requirements of section 5309(e) installed. |

Table 53-X
**FAN SIZES FOR BASEMENT[1] PRESSURIZATION SYSTEMS**

| Area (sq.ft.) | Flow Rates CFM[2] |
|---|---|
| 250 | 25 |
| 500 | 27 |
| 750 | 40 |
| 1000 | 53 |
| 1250 | 67 |
| 1500 | 80 |
| 1750 | 93 |
| 2000 | 107 |
| 2500 | 133 |
| 3000 | 160 |
| 3500 | 187 |

[1]basement areas at 8' height.
[2]0.4 air change per hour capacity.

TABLE 53-Y
**FAN FOR ACTIVE CRAWLSPACE VENTILATION SYSTEMS**

**Flow Rates For Various Crawlspace Areas And Average Heights (CFM)**

| Area-sf | 18" High or less | 24" High | 30" High | 36" High or more |
|---|---|---|---|---|
| 250 | 25 | 25 | 25 | 25 |
| 500 | 25 | 33 | 42 | 50 |
| 750 | 38 | 50 | 62 | 75 |
| 1000 | 50 | 67 | 83 | 100 |
| 1250 | 62 | 83 | 104 | 125 |
| 1500 | 75 | 100 | 125 | 150 |
| 1750 | 88 | 117 | 146 | 175 |
| 2000 | 100 | 133 | 167 | 200 |
| 2500 | 125 | 167 | 208 | 250 |
| 3000 | 150 | 200 | 250 | 300 |
| 3500 | 175 | 233 | 292 | 350 |
| 4000 | 200 | 267 | 333 | 400 |
| 5000 | 250 | 333 | 417 | 500 |

## Optional Calculation for Connected Interior Lighting Budget

**Sec. 5310. (a) General.** This calculation procedure may be used to determine compliance with Section 505.3.2 of this code. It is intended to permit design flexibility in meeting special illumination needs sometimes found in office and sales areas. The interior budget calculated using this procedure may be used when approved by the Building Official.

(b) **Optional Calculation for Maximum Interior Connected Lighting Load.** The watts of the building's interior connected lighting load shall be no more than the maximum calculated in Section 5310(b)1. This section shall be used only if the plans and specifications submitted under this Code shows the occupancy and use in each space.

1. Calculate the maximum connected lighting load for lighting inside the building envelope as indicated below as a summation of wattage allotments determined for individual areas, rooms, and task locations in the building envelope as shown in the required plans, based on the illuminance category and the room cavity ratio (RCR) calculated as shown in Equation 10.1.

$$RCR = 5H(L + W)/LW \quad \text{................Equation 10-1}$$

Where: RCR = Room Cavity Ratio
H = Vertical distance from work plane to lighting fixture (FT)
L = Length of room (FT)
W = Width of room (FT)

A. For offices the appropriate illuminance category for each area/activity shall be selected from the Office Lighting American National Standard Practice, ANSI/IES RP-1 1982.

Spaces designated for illuminance category F and higher shall be identified on the plans and specifications submitted under this Code showing locations of individual tasks and equipment to provide illumination of those tasks.

The illuminance category for visual task requirements selected for each task space shall not be based upon an incidental task or combination of tasks which specify use of a given illuminance category or higher when the incidence of these tasks totals less than two hours per working day.

Selection of a higher level illuminance category to accommodate poor quality tasks shall be permitted only if task quality cannot be improved. Task quality may be improved if the equipment or procedure that produces the poor quality task is controlled by the occupant. Tasks with quality that cannot be improved are generated outside of the control of the business of the occupant working with these tasks. a "poor quality task" is a visual task that requires illuminance category "E" or greater and is due to choice of a writing or printing method that produces characters that are of smaller size or lower contrast than good quality alternatives that are regularly used in offices. Poor quality tasks include the following:

Ditto copy
Thermal copy, poor copy
Xerography, 3rd generation or greater
Thermal printer
Impact printer, 2nd carbon or later
Typed print, 2nd carbon or later
Printing 6 pt type
Handwritten carbon copies
Handwritten #4 and harder pencil

Examples of good quality alternatives which are regularly used in offices and which may be selected to replace one of the above poor quality tasks include:

Mimeograph and xerograph copy
Impact printers with good ribbon
Typed originals in 8 pt and larger type
Handwritten originals in #2 pencil or pen

B. For retail and wholesale stores, the lighting power level for merchandising and associated service areas of stores as defined in Table 1 of the Illuminating Engineering Society Publication, "RP2" Recommended Practice for Lighting Merchandising Areas, shall be the Table 10-1 watts per square foot listed for the illuminance categories shown in Table 10-2.

The watts per square foot value shall be determined as a weighted average of the Table 10-1 values based upon the actual number of displays in each task area/throw distance category.

In areas where luminaries must be at or above 15 foot mounting heights the allotment may be increased by the following multipliers:

| Required Mounting Height (feet) | Multiplier |
|---|---|
| 15 | 1.15 |
| 16 | 1.21 |
| 17 | 1.47 |
| 18 | 1.65 |
| 19 | 1.84 |
| 20 | 2.04 |

Allotments calculated for floor mounted displays and wall mounted displays are separate and any excess wattage above what is actually installed for one may not be added to the allotment of the other.

Areas established for determining feature display allotments need not be excluded from calculation of gross sales area allotment. Feature display allotments are in addition to the gross sales area allotment.

**EXCEPTIONS:** 1. If detailed documentation of actual areas with specific dimensions of al feature displays and each luminaire designated for each of these displays is provided, the feature display allotment may be used up to a maximum of 10 percent of the gross sales area.

2. If very valuable merchandise, not directly accessible to the customer, is presented as feature displays in floor mounted, counter cases that are externally lighted from above; an allotment of 20 watts per square foot times the actual area of lighted case top may be used. Detailed documentation on plans must show actual placement with specific dimensions of enclosed counter display cases and each luminaire designated to provide lighting for each case.

Note: Very valuable merchandise includes: jewelry, rare coins, small art objects and similar items where selling involves customer inspection of very fine detail from outside of a locked counter case.

Office spaces in retail buildings shall have lighting power allotments based upon provisions of A above.

C. For spaces in either office or retail buildings which are not covered by provisions of Section A or (2) above, the appropriate illuminance category shall be selected from the IES Lighting Handbook, 1981 Reference Volume, Appendix A, Figure 2-2.

D. Calculate the allotted watts for each space by multiplying the square feet of area by the watts per square foot value for the selected illuminance categories A, B, C and D, the entire space is allotted the designated watts per square foot value for the category. For illuminance categories E and F, a task oriented lighting allotment at the designated watts per square foot value for the category is allowed a general lighting allotment at one-third the designated watts per square foot value for the category. For illuminance categories G, H and I, the allotted watts per square foot value for the category shall be allowed for only the actual task area as shown on the plans. For illuminance categories A through F, if values from RCR columns "RCR 3.5 to 7+" are used, calculation of the RCR shall be made from Equation 10-1.

E. The total allotted watts shall be determined as the summation of allotted watts for all A, B, C, D, E and F illuminance category spaces plus either the allotted watts or actual design watts, whichever is smaller, for each G, H and I illuminance category space.

F. Multiple allotments for the same space are allowed if two or more distinctly different lighting systems are required for multiple use of the space and are independently circuited and interlocked to permit only one system to be operated at a time.

2. **Lighting Controls.** For the purpose of demonstrating compliance with Section 1 above, the design lighting watts of the building may be adjusted for lighting controls in accordance with Equation 10-2.

Equation 10-2

$$ACLL = \frac{[(W_T - CW_1)(PSAF_1) - (CW_2)(PSAF_2) - \ldots - (CW_n)(PSAFn)]}{CFA}$$

**Where**

| | | |
|---|---|---|
| ACLL | = | adjusted connected lighting load |
| $W_T$ | = | total lighting watts in building |
| $CW_{1,2,\ldots,n}$ | = | watts of lighting in space 1,2,...,n with controls as specified in Table 10-3. |
| $PSAF_{1,2,\ldots,n}$ | = | power savings adjustment factor for space 1,2,...,n, as specified in Table 10-2 |
| CFA | = | conditioned floor area of the building |

## Table 10-1. WATTS PER SQUARE FOOT VALUES APPLICABLE TO OFFICES, RETAIL & WHOLESALE STORES

| Illuminance Category** | Watt Per Square Foot RCR 0 to 3.5 | RCR 3.5+ to 7 | RCR 7+ | See Note |
|---|---|---|---|---|
| A(3) | .2 | .3 | .4 | -- |
| B(7.5) | .4 | .5 | .8 | -- |
| C(15) | .6 | .8 | 1.2 | -- |
| D(30) | 1.2 | 1.5 | 1.8 | -- |
| E(75) | 2.8 | 3.6 | 4.7 | 1 |
| F(150) | 5.0 | 6.0 | 10.1 | 1 |

| | Task Area $< 2$ ft$^2$ or Throw Distance* $> 8$ ft | Task Area $\geq 2$ ft$^2$ | See Note |
|---|---|---|---|
| G(300) | 26 | 13 | 1 |
| H(750) | 63 | 33 | 1 |
| I(1,500) | 130 | 65 | 1 |

* "Throw Distance" is defined as distance, documented on plans, between luminaire and center of lighted plane on a feature display.

** Numbers in parentheses are the mid-range footcandle levels for the illuminance category.

NOTES TO TABLE 10-1:

1. Maximum connected lighting load for these tasks shall be based on a combination of general and task-oriented lighting. Lighting for these tasks or retail feature displays shall be obtained by local lighting, and shall be confined to the specific task area, which shall be described. For store feature displays, each feature display and identification of its lighting equipment shall be shown on plans. Any lighting power allotment determined for these tasks, that is more than the lighting power level actually installed, shall not be applied to other task areas.

TABLE 10-2

| Area or Task | Designate as Illuminance Category |
|---|---|
| Gross Sales Area [1] | D |
| Valance[2] | F |
| Feature Displays[3] | G |
| Show Windows | G |
| All Others | See Section 1001.2.1.3 |

FOOTNOTES TO TABLE 10-2:

1. Gross sales area equals the total of merchandise, display, sales transaction, fitting room and associated circulation and entry areas.

2. Valance lighting is defined, for the purpose of determining its power allotment, as a system of luminaries arranged to provide accent lighting power illumination along a wall surface. The valance lighting power allotment equals the task-oriented watts per square foot value shown for illuminance category F and RCR 0 to 3.5 multiplied by the area formed by multiplying a two foot wall surface width times the florescent luminaire length. This is equivalent to 10 watts per linear foot times the fluorescent luminaire length.

Detailed dimensioned documentation on plans must be shown when an allotment is taken for more than one tier of valance luminaries. To qualify as a separate tier, a minimum of 2 feet vertical separation between valances must exist. For valance lighting systems using other than fluorescent types of luminaries, the area used for the allotment shall be calculated as the length of accented wall times a two foot wall surface width.

3. Feature display is defined as an item or items requiring special highlighting to visually attract attention and set apart from the surrounding area. Such items in stores larger than 1,000 square foot are not a part of merchandise directly assessable to customers.

The lighting power allotment for feature display shall be:

a. The greater of 1000 watts or the wattage determined by multiplying the Table 10-1 watts per square foot value times 5 percent of the gross sales area; an

FOOTNOTES 10-2 CONTINUED

b. Where lighting is provided for wall mounted feature displays, a separate additional allotment equal to the wattage determined by multiplying the Table 10-1 watts per square foot value times 10 percent of the total wall area in the gross sales area, excluding fitting rooms. When valance lighting is installed, the wall display allotment calculation shall exclude an area equal to the valance length times six feet for the first tier and times two feet for subsequent tiers of valance.

TABLE 10-3 ADJUSTMENT FACTORS FOR SPECIAL LIGHTING CONTROLS[1]

| Control Type | Power Savings Adjustment Factor[2] | Applicable Building Spaces(s) |
|---|---|---|
| Occupant-Sensing Devices[3,5] | 0.30 | Any single space up to 250 square feet and enclosed by ceiling height partitions; classroom, conference rooms, computer rooms, storage areas, corridors or waiting rooms. |
| Daylighting Controls[4,5] | | Any daylit space[6] |
| Continuous Dimming | 0.30 | |
| Stepped Controls | 0.20 | |
| Programmable Timing Controls[7] | 0.15 | Any space |
| Lumen Maintenance Controls[5] | 0.10 | Any space |
| Daylighting Controls[4,5] with Occupant Sensing Devices | 0.44 | Any single space up 250 square feet within daylit spaces and enclosed by ceiling height partitions |
| Occupant Sensing Devices[3,5] with Lumen Maintenance Controls | 0.37 | Any single space up to 250 square feet and enclosed by ceiling height partitions |

FOOTNOTES TO TABLE 10-3:

1. Adjustment factor shall be allowed for controls required under provisions of Section 5305(e)4. Dimming controls of incandescent lamps or luminaries shall not qualify.
2. Except as shown, only one adjustment factor may be used for each building space or luminaire, and 50% or more of the luminaire shall be within the applicable space to qualify

**FOOTNOTES TO TABLE 10-3 CONTINUED:**

for the power savings adjustment factor. These controls must be installed in series with the lights and in series with all manual switching devices in order to qualify for an adjustment factor.

3. To qualify for the power savings adjustment factor, occupant-sensing device shall meet the criteria to Section 5305(d)1B. Separate sensors and switching must be provided for each enclosed space or area.

4. Daylighting controls shall be able to reduce electric power consumption for the controlled lighting to 50 percent or less of maximum power consumption, shall control all luminaries delivering more than 50 percent of its light output to surfaces outside daylit spaces.

5. Lighting controls shall meet the requirements of Section 5305(d).

6. The daylit space must be illuminated by either:

a. Glazing in walls more than 3 feet in vertical extent with its highest edge 4 or more feet above the floor of the daylit area; or

b. Glazing in roofs with sash, 2 square feet or more in area.

7. Programmable timing controls used for credit in conjunction with Table 10-2 must be capable of:

a. Programming different schedules for weekdays and weekends; and

b. Temporary overrides by occupant with automatic return to the original schedules. Override controls shall be readily accessible; and

c. Providing independent control of each lighting load which is required to be separately controlled Section 5305(d)1B does not apply and provisions of Section 5305(d)1E must be met.

# CONVERSION STANDARD

# EQUIVALENT CODE AMENDMENTS

to the

# MODEL ENERGY CODE

December 24, 1986

CABO Format

TABLE OF CONTENTS


| CHAPTER | | PAGE |
|---|---|---|
| 1. | ADMINISTRATION AND ENFORCEMENT | 1 |
| 101 | SCOPE AND GENERAL REQUIREMENTS | 1 |
| 102 | MATERIALS AND EQUIPMENT | 3 |
| 103 | ALTERNATE MATERIALS--METHOD OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS | 3 |
| 104 | PLANS AND SPECIFICATIONS | 4 |
| 105 | ENFORCEMENT AND INSPECTIONS | 4 |
| 106 | VALIDITY | 5 |
| 107 | VIOLATIONS AND PENALTIES | 5 |
| 108 | LIABILITIES | 5 |
| 2. | DEFINITIONS | 6 |
| 201 | GENERAL DEFINITIONS | 6 |
| 3. | DESIGN CONDITIONS | 11 |
| 302 | THERMAL DESIGN PARAMETERS | 12 |
| 4. | BUILDING DESIGN BY SYSTEMS ANALYSIS | 13 |
| 401 | SCOPE | 13 |
| 5. | BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH | 15 |
| 501 | SCOPE | 15 |
| 502 | BUILDING ENVELOPE REQUIREMENTS--RESIDENTIAL | 15 |
| 503 | BUILDING MECHANICAL SYSTEMS--NON-RESIDENTIAL | 27 |
| 504 | SERVICE WATER HEATING - RESIDENTIAL AND NON-RESIDENTIAL | 30 |
| 505 | ELECTRICAL POWER AND LIGHTING--NON-RESIDENTIAL | 31 |
| 506 | ELECTRIC ENERGY AUDIT | 36 |
| 6. | BUILDING DESIGN BY PRESCRIPTIVE REQUIREMENTS APPROACH | 38 |
| 601 | SCOPE | 38 |
| 602 | BUILDING ENVELOPE | 39 |

ACKNOWLEDGEMENTS

The Bonneville Power Administration acknowledged that although these amendments use the same format as The Model Energy Code 1983 edition published and copyrighted by the Council of American Building Officials, the technical requirements contained therein are NOT the same as the Model Energy Code and are NOT based on a national consensus. These amendments are designed to be used with and compatible with the Model Energy Code 1983.

Credit is given to John F. Hogan, Major Projects Energy Analyst, City of Seattle, Department of Construction and Land Use (DCLU), for development. Tom Eckman of the Northwest Power Planning Council, and Suzanne Rowan, of BPA's Office of Conservation, provided technical review assistance. This work is the result of a purchase order between BPA's Puget Sound Area Office (PSAO) and DCLU. Substantial purchase order related support was provided by Frank Brown and Dulce Setterfield of the PSAO.

Graditude for continued support and encouragement for this project is expressed to: Richard P. Kuchnicki, President, Council of American Building Officials; and, David A. Bassett, President, International Council of Building Officials.

MEC CONVERSION EQUIVALENT CODE

FINAL DRAFT - DECEMBER 24, 1986

# CHAPTER 1

# ADMINISTRATION AND ENFORCEMENT

## SECTION 101

## SCOPE AND GENERAL REQUIREMENTS

### 101.1 Title

This code shall be known as the MCS Conversion Standard Equivalent Code, and may be cited as such. It is referred to herein as "this code."

### 101.2 Intent

The provisions of this code shall regulate residential buildings whose new or enlarged electric service is for electric space heat and is converted from any other fuel. This code shall regulate non-residential buildings, or portions thereof, whose new or enlarged electric service is for space conditioning.

Authority for the provisions of this code comes from the Northwest Power Planning Council's "Northwest Conservation and Electric Power Plan," 1986, Volume One, page 9-9, Section 3, "Residential and Commercial Buildings Converting to Electric Space Conditioning."

> EXCEPTION: In lieu of the specific provisions of this code, a package of efficiency measures which can be shown to achieve savings comparable to those which would be achieved by incorporating all efficiency improvements up to the regionally cost-effective level may be substituted.

Residential provisions of this code are intended to provide the flexibility to permit the use of innovative approaches and techniques for achieving the efficient use of energy for space heating and hot water heating. These provisions are structured to permit compliance by one of up to three paths:

- A systems approach for the entire building, Chapter 4;

- A component performance approach for various building elements and mechanical systems, Chapter 5; or

- A perscriptive approach, Chapter 6.

Non-residential provisions of this code require the following:

- Compliance with service water heating minimums,
- Piping and ducting insulation minimums,
- Lighting power budgets, and
- Submission of an electric energy audit to the servicing utility or local government.

EXCEPTION: Non-residential customers whose new or enlarged service connection is for purposes other than electric space conditioning need not submit the electric energy analysis or incorporate efficiency upgrades.

101.3 Scope

This code sets forth minimum requirements for connecting new or enlarged electric service for electric space heat in existing residential and non-residential buildings.

EXCEPTION: The code in effect on the date of the permit application will remain in effect until the permit expires, is rescinded, or is completed.

This code is intended to supplement the provisions of the Uniform Building Code, the Uniform Mechancial Code, and the National Electrical Code, the Uniform Plumbing Code, the Uniform Fire Code, and in case of conflict between this code and any of those codes with respect to the efficient use of electricity, the provisions of those codes shall apply. In any case where a Federal, state or local code or regulation exceeds this code's requirements with respect to securing more efficient use of electric energy, that code or regulation shall apply.

101.3.1 Exempt Buildings

Buildings and structures, or portions thereof, meeting any of the following criteria shall be exempt from the requirements of this code.

101.3.1.1 Buildings which are designated as historic landmarks to the extent necessary to preserve those features necessary for their historic appearance or function.

101.3.1.2 Temporary services, construction services, and replacement services which do not increase the amperage capacity of the incoming service.

101.3.3 Where the structural elements of the roof/ceiling, wall or floor area are not being replaced, alternations and repairs shall not be deemed to comply with opaque envelope standards if all existing framing cavities are filled to their full depth with batt insulation or insulation of an equivalent nominal R-value while, where necessary, maintaining space for ventilation.

## SECTION 102

## MATERIALS AND EQUIPMENT

### 102.1 Identification

Building (M)materials and equipment shall be identified in order to show compliance with this code.

### 102.2 Maintenance Information

Required regular maintenance actions shall be clearly stated and incorporated on a visible 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 equipment which requires preventive maintenance for efficient operation.

## SECTION 103

## ALTERNATE MATERIALS--METHOD OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS

The provisions of this code are not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been approved by the Building Official as meeting the intent of the code.

EXCEPTION: In cases where a building permit is not necessary, inspection by a utility service representative is required.

## SECTION 104

## PLANS AND SPECIFICATIONS

The existing building envelope component R values shall be specified and may be verified by the Building Official.

## SECTION 105

## ENFORCEMENT AND INSPECTIONS

### 105.1 General

The Building Official is authorized and directed to enforce this code. Construction or work for which a permit is required shall be subject to inspection by the Building Official in connection with inspections performed pursuant to the building, mechanical, plumbing, fire, and electrical codes.

### 105.2 Inspection

Before the utility or any governmental agency shall approve for connection any new or enlarged electric service for electric space heat in any residential or non-residential building, the Building Official shall be contacted to inspect the premises for compliance.

### 105.3 Approvals Required

No new or enlarged electric service to be used for the purpose of converting to space heat shall be permanently connected by the utility in a non-residential building granted a buiding permit before the adoption of this code, without complying with the following:

- Submitting the results of an electric energy audit performed in accordance with section 506 to the Building Official in their format;

- Requirements for duct and pipe insulation and service hot water heating if the system is converted to electric water heating;

- Lighting power budgets and forms as required if improvements are made to the lighting system.

## SECTION 106

## VALIDITY

If a 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 107

## VIOLATIONS AND PENALTIES

It shall be unlawful for any person, firm or corporation to convert to electric use any building or structure contrary to or in violation of any of the provisions of this code.

Anyone concerned in the violation or failure to comply with these provisions, whether directly committing the act or effecting the omission constituting the offense or aiding or abetting the same whether present or absent; and anyone who directly or indirectly counsels, encourages, hires, commends, induces or otherwise procures another to violate or fail to comply with these provisions, is and shall be an offender under the terms of this code and shall be proceeded against and prosecuted as such.

## SECTION 108

## 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 the enforcing local government or utility, for any injury or damage resulting from the failure of a building to conform to the provisions of this code, or by reason of in consequence of any inspection, notice, order, certificate, permission of approval authorized or issued or done in connection with the implementation or enforcement of this code, or by reason or any action or inaction on the part of the local government or servicing utility related in any manner to the enforcement of this code or by its officers or agents.

The Building Official charged with the enforcement of this code, acting in good faith and without malice, shall not thereby be personally liable and is hereby relieved of all personal liability for any damage that may accrue to persons or property as a result of any act required or by reason of any act or omission in the discharge of duties. Any suit brought against the Building Official or employee because of such act or omission performed while enforcing any provision of this code shall be defended by legal counsel provided by the jurisdiction until termination of such proceedings.

# CHAPTER 2

# DEFINITIONS

## SECTION 201

## GENERAL DEFINITIONS

### 201.1 Application of Terms

For the purposes of this code, certain abbreviations, terms, phrases, words, and their derivations, shall be as set forth in this chapter.

APARTMENT HOUSE. Any building or portion thereof which contains three or more dwelling units.

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. (See MANUAL.)

BELOW GRADE WALL. A wall or section thereof which encloses conditioned space but is not exposed to outdoor air.

BRITISH THERMAL UNIT (Btu). The amount of heat required to raise the temperature of one pound of water by one Fahrenheit degree.

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

BUILDING OFFICIAL. The official authorized to act in behalf of the responsible govenment agency for the enforcement of this code.

CONDITIONED FLOOR AREA. The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

CONDITIONED SPACE. Space within a building which is five (5) feet or more in height from finished floor to finished ceiling and which is conditioned directly or indirectly by an energy-using system capable of maintaining a temperature of 50°F or higher for heating and/or 85°F or below for cooling. It shall also include spaces with humidification or dehumidification means so as to be capable of maintaining a space condition falling within the comfort zone set forth in Standard RS-4. Enclosed corridors between conditioned spaces shall be considered as conditioned space.

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.

DWELLING UNIT. (See "Uniform Building Code.")

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

EXTERIOR WALL. A wall, or section thereof, which is exposed to an exterior ambient condition and encloses conditioned space.

FLOOR OVER UNCONDITIONED SPACE (ENCLOSED). A floor which separated a conditioned space from an unconditioned space which if buffered from ambient weather conditions including vented crawl spaces and unconditioned basements or other similar spaces.

FLOOR OVER UNCONDITIONED SPACE (EXPOSED). A floor which separates a conditioned space from an unconditioned space exposed to outdoor weather conditions including open parking garages and enclosed garages which are mechanically ventilated.

GLAZING. All areas including frames in the shell of a conditioned space that let in natural light, including windows, clerestories, skylights, sliding glass doors, glass brick walls, and the glazed portions of doors.

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

GROSS FLOOR AREA. The sum of the area of the several floors of a building, including basements, cellars, mezzanine and intermediate floored tiers and penthouses of headroom height, measured from the interior faces of exterior walls (see Section 407, Uniform Building Code), but excluding:

Covered walkways, open roofed-over areas, porches and similar spaces. Pipe trenches, exterior terraces or steps, chimneys, roof overhangs and similar features.

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

GROSS EXTERIOR 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, and door areas. The gross area of exterior walls consists of all opaque walls areas, including foundation walls, 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 conditioned space including interstitial areas between two such spaces.

GROUP R OCCUPANCY DIVISION 1. Hotels and apartment houses.

GROUP R OCCUPANCY DIVISION 3. Detached one- and two-family dwellings and lodging houses.

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

HEATED SPACE. Space within a building which is provided with a positive heat supply. Finished living space within a basement or registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space.

HEATING SEASON PERFORMANCE FACTOR (HSPF). The total heating output (in Btu) of a heat pump during its normal annual usage period for heating divided by the total (watt hour) electric power input during the same period, as determined by test procedures consistent with the U.S. Department of Energy "Test Procedure for Central Air Conditioners, Including Heat Pumps" published in the December 27, 1979, Federal Register, Vol. 44, No. 24, IOCFR. 430 When specified in Btu per watt hour an HSPF of 6.826 is equivalent to an HSPF of 2.0 watt hour per watt hour.

HVAC. Heating, ventilating, and air conditioning.

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

LOW-RISE BUILDING. A building not exceeding three stories of conditioned space in height.

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

MANUAL. Capable of being operated by personal intervention. (See AUTOMATIC.)

MAY. Where "may" is used in a specific provision, that provision is permissible.

NOMINAL R VALUE. The thermal resistance of insulation material only as specified by the manufacturer according to the recognized trade and engineering standards or approved equivalent.

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

OPERABLE WINDOW INSULATION. Movable window covers of insulating material which have means to create an edge fit better than a loose fit (i.e., interlocking edge, cushion seal, mechanical, or magnetic seal) and with a minimum thermal resistance of R-5.

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

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

POWER. The rate at which electric energy is transmitted; in customary units, measured in watts (W) or British thermal units per hour (Btu/h).

ROOF/CEILING ASSEMBLY. A roof/ceiling assembly shall be considered as all components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to an exterior ambient and encloses conditioned space. This does not include elements which are separated from a conditioned space by a vented air space.

The gross area of a roof/ceiling assembly consists of the total interior surface of such assembly, including skylights exposed to the conditioned space.

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

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

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

SHOULD. Not mandatory but desirable as good practice.

SKYLIGHT. A glazed opening in a roof/ceiling assembly, consisting of a supporting structure with glass, plastic or similar material tilted up from the horizontal less than sixty (60) degrees.

SLAB-ON-GRADE FLOOR. Any slab poured in contact with the ground and for which the top of the finished slab is less than 24 inches below the final elevation of the nearest exterior grade.

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

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

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

THERMAL CONDUCTANCE (C). The thermal transmission in unit time through unit average temperature is established between surfaced (Btu/h/ft$^2$/$^o$F).

THERMAL RESISTANCE (R). The reciprocal of thermal transmission (Btu/h/ft$^2$/$^o$F).

THERMAL TRANSMITTANCE, OVERALL ($U_o$). The overall coefficient of the heat transmission (air-to-air) due only to the difference in indoor and outdoor air temperatures of a gross area of the exterior building envelope (Btu/h/ft$^2$/$^o$F). The $U_o$ value applies to the combined effect of the time rate of heat flows through the various parallel paths, such as window, doors and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/ceiling.

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

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

VAPOR RETARDER. A layer of low moisture transmissivity material (not more than 1.0 perm dry cup) which is placed over the warm side (in winter) of insulation, over the exterior of below grade walls, and under floors as ground cover to limit the diffusion of water and water vapor through exterior walls, ceilings and floors. The layer may or may not be an integral part of the insulation and may or may not be continuous.

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

UTILITY REPRESENTATIVE. The agent authorized to act in behalf of the responsible utility.

# CHAPTER 3

# DESIGN CONDITIONS

## SECTION 301

### 301.1 General

The criteria of this chapter establish the minimum thermal requirements of the exterior envelope.

### 301.2 (Reserved)

### 301.3 Mixed Occupancy

When a building houses more than one occupancy, each portion of the building shall conform to the requirements for the occupancy housed therein. Where minor accessory uses do not occupy more than 10 percent of the area of any floor of a building, the major use shall be considered the building occupancy.

### 301.4 Moisture

Conversions under the provisions of this code shall not create conditions of accelerated deterioration from moisture condensation.

## SECTION 302

## THERMAL DESIGN PARAMETERS

### 302.1 Exterior Design Conditions

The following design parameters shall be used for calculations required under this code:

| EXTERIOR DESIGN CONDITIONS | | |
|---|---|---|
| Winter[1] | Design Dry-bulb | °F |
| Summer[1] | Design Dry-bulb | °F |
| | Design Wet-bulb | °F |

| | |
|---|---|
| DEGREE DAYS HEATING | |
| DEGREES NORTH LATITUDE | |

1 The outdoor design temperature shall be selected from the column of 97.5 percent values for winter and 2.5 percent values for summer from Table 1, Chapter 24, ASHRAE HANDBOOK 1985 FUNDAMENTALS. Adjustments may be made to reflect local climates which differ from the tabulated temperatures, or local weather experience as determined by the Building Official.

### 302.2 Interior Design Conditions

The indoor design temperature in non-residential buildings shall be 70°F for minimum heating and 78°F for maximum cooling.

# CHAPTER 4

# BUILDING DESIGN BY SYSTEMS ANALYSIS

## SECTION 401

## SCOPE

401.1 General

This chapter establishes design criteria in terms of total energy use for space heating by low-rise residential buildings and total energy use, including all systems, for non-residential buildings.

402.1 (Reserved)

402.2 (Reserved)

402.3 (Reserved)

402.4 (Reserved)

402.5 (Reserved)

402.6.1 Energy Budgets. A low-rise residential building being converted to electric space heat designed in accordance with this section shall be designed to use no more kilowatt hours (kwh) of electric energy from depletable sources than a building of similar design whose envelope and energy consuming systems are designed in accordance with chapter 5 of this code.

402.6.2 Calculation of Energy Consumption. Compliance by means of this section shall include documentation which demonstrates that the proposed buildings space heating energy use does not exceed the space heating energy use of a similar building conforming to chapter 5 of this code. The calculation procedure must be approved by the Building Official.

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

MEC CONVERSION EQUIVALENT CODE

| Parameter | Value |
|---|---|
| Thermostat set point, heating | 65°F |
| Thermostat set point, cooling | 78°F |
| Thermostat night set back | None |
| Internal gain from lights, appliances and occupants (per dwelling unit) | 3000 Btu/°F per sq ft 72,000 Btu/day |
| Minimum heat storage capacity | 3 Btu/°F per sq ft of conditioned floor area |
| Site shading | Actual solar shading for the building site |
| Weather data | Typical meterorological year (TMY) or other appropriate site(s) as approved |
| Heating season average wind speed | 7.5 mph (outside) |

402.6.4 Infiltration. Infiltration level used in the proposed design shall be consistent with the infiltration level used in the standard design or the designer shall provide documentation for alternate assumptions.

402.6.5 Heat Pumps. When electricially driven heat pumps using depletable energy sources are employed to provide all or part of the heat for the alternate design, the standard design shall also assume that an electrically driven heat pump having at least the same capacity as that used in the alternae design.

The heating season performance factor (HSPF) for heat pumps installed in low-rise dwellings and apartments shall be calculated using procedures consistent with section 5.2 of the U.S. Department of Energy Test Procedure for Central Air Conditioners, including heat pumps published in the December 27, 1979 Federal Register Vol. 44, No. 24.10 CFR 430. Climate data as specified above, the proposed buildings overall thermal performance value (Btu/°F) and the standardized input assumptions specified above shall be used to model the heat pump HSPF.

# CHAPTER 5

# BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH

## SECTION 501

## SCOPE

501.1 General

Residential buildings being converted to electric space heat shall follow the requirements contained in section 502 and 504 of this chapter and shall meet the overall thermal performance requirements specified therein.

Non-residential buildings shall follow the requirements in section 503, 504, and 505 of this chapter.

## SECTION 502

## BUILDING ENVELOPE REQURIEMENTS--RESIDENTIAL

502.1 General

The building envelope requirement of this code shall be met by installing the component package in Table 5-1. The stated $U_o$ of any one element of a building, such as roof/ceiling, wall, or floor, may be increased and the $U_o$ for other components decreased, provided that the overall heat gain or loss for the entire building envelope does not exceed the total resulting from those in Table 5-1.

502.2.1 Insulation. All insulation materials shall be placed in the building shell in such a manner as to provide for the uniform R value. Tapering of ceiling insulation at roof edges is permissible to allow proper venting.

502.2.1.1 (Reserved)

502.2.1.2 Loose fill insulation may be used in attic spaces where the slope of the roof is not less than 2-1/2 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 joists to the underside of the roof sheathing at the roof ridge. The surface of the installed blown or poured insulation shall be baffled. Baffles shall be of weather-resistant, rigid material capable of retaining the insulation.

502.2.1.3 (Reserved)

502.2.1.4 (Reserved)

502.2.1.5 (Reserved)

502.2.1.6 (Reserved)

502.2.1.7 (Reserved)

502.2.1.8 Below grade wall insulation shall extend from the top of the wall to the top of the footing or floor slab. If installed on the exterior, the below grade wall insulation shall be protected and if exposed on the interior, it shall comply with Section 1712 of the Uniform Building Code.

502.2.1.9 Slab-on-grade floor insulation shall extend downward from the top of the slab to the design frost line or a minimum distance of 24 inches, whichever is greater. If the depth of the footing is less than 24 inches, then the insulation shall extend downward to the bottom of the slab or to the base of the foundation footing. Insulation shall be of an approved type.

EXCEPTION: For monolithic slabs, the insulation shall extend downward from the top of the slab to the bottom of the thickened edge.

502.2.2 Ventilation

502.2.1 Cross ventilation shall be maintained above all ceiling insulation installed on the interior of the roof structure by providing both low and high vents or gable and vents. Thermal insulation shall not be installed in a manner that obstructs required attic ventilation. Enclosed joist or rafter spaces formed where ceilings are applied directly to the underside of roof joists or rafters must have joists or rafters of sufficient size to provide a minimum of one inch clear vented air space above the insulation. (See also Section 3205(c) of the Uniform Building Code.)

502.2.2 Crawl spaces shall be ventilated by openings in exterior foundation walls. Such openings shall have a net area of not less than one square foot for each 150 space feet or *underfloor area. Openings shall be located as close to corners as practical and shall provide cross ventilation. (See Uniform Building Code, Section 2516(c)6.)

502.2.3 Moisture Control. Where a vapor retarder is specified, it shall be installed facing the conditioned space.

502.2.3.1 (Reserved)

502.2.3.2 Exterior ceilings shall have a vapor retarder with 0.5 perm dry cup rating or less when thermal insulation is installed. Where ceilings are deck and beam construction exposed to the conditioned space, the vapor retarder shall be placed on top of the decking.

502.2.3.3 Floors shall have a vapor retarder installed according to manufacturer's specifications and have a dry cup rating of not more than 1.0 perm when thermal insulation is installed. The vapor retarder need not be an integral part of the insulation material.

502.2.3.4 A ground cover of 6 mil opaque polyethylene or other approved material with a dry cup rating of not more than 1.0 perm shall be installed on the ground in crawl spaces when thermal insulation is installed.

502.3.1 Opaque envelope criteria.

502.3.1.1 Walls. For any low-rise residential building that is mechanically heated and/or cooled, the overall thermal transmittance value ($U_o$ of the gross wall area of exterior walls shall not exceed the value given in Table 5-1. Equations 1 and 2 shall be used to determine acceptable combinations to meet this requirement.

502.3.1.2 Roof/ceilings. For any low-rise residential building that is heated and/or mechanically cooled, the overall thermal transmittance value ($U_o$) for the gross roof/ceiling area shall not exceed the value given in Table 5-1. Equations 1 and 3 shall be used to determine acceptable combinations to meet this requirement.

502.3.1.3 Floors over unconditioned spaces. For any low-rise residential building being converted to electric space heat, the overall thermal transmittance value ($U_o$) for floors exposed to outside air, such as floors over vented crawl spaces, garages, or overhangs, shall not exceed the value given in Table 5-1. For any other low-rise residential building being converted to electric space heat, the overall thermal transmittance value ($U_o$) for all other floors over unconditioned spaces shall not exceed the value given in Table 5-1.

502.3.1.4 Slab-on-grade floors. For slab-on-grade floors, the thermal resistance value (R) of the insulation around the perimeter of the floor shall not be less than the value given in Table 5-1.

502.3.2 Glazing Criteria.

502.3.2.1 Passive solar exemption. Subject to the following limitations, glazing areas in low-rise dwellings and apartments which qualify by meeting all of the criteria below may be exempted from the $U_o$ calculations.

502.3.2.2 The glazing shall be double glazing at a minimum. Insulating glass with at least 1/2 inch air space or approved storm sash shall be considered to comply with this code.

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

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

502.3.2.5 The single glazed storm sash shall have a transmission coefficient greater than or equal to 0.80 for visible light or 0.73 for total solar radiation for a single pane. The insulating glass unit shall have total visible light transmission equal to or greater than 0.67 and total solar energy transmission equal to or greater than 0.55.

502.3.2.6 Documentation in the form of a sun chart, photograph or other evidence demonstrates that the glazing area oriented within 30 degrees of true south must receive direct solar exposure for at least 3 hours between 10 a.m. and 2 p.m. solar time on January 21st and March 21st.

502.3.2.7 Documentation in the form of a sun chart, photograph or other evidence demonstrates that the glazing area oriented between 31 and 45 degrees east or west of true south must receive direct solar exposure for at least 2 hours between 9 a.m. and 12 noon solar time if east of south, and 12 noon and 3 p.m. solar time if west of south on January 21st and March 21st.

502.3.2.8 The building or addition shall contain a heat storage capacity equivalent to at least 20 Btu/°F for each square foot of solar glazing when the qualifying area is between eight (8) and fourteen (14) percent of the gross habitable conditioned floor area of the building and at least 45

Btu/°F for each square foot of solar glazing when the qualifying area exceeds fourteen (14) percent of the gross conditioned floor area of the building. This heat storage capacity shall be 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. If the storage medium is not within the space containing the qualifying glazing, an acceptable natural or mechanical means of transferring the heat to the heat storage medium shall be provided. Where a mass- or water-wall is located immediately behind the glazing, the mass- or water-wall shall be considered as having an acceptable natural means of transferring the heat to other heat storage capacity within that space. Heat storage capacity shall be calculated using Equation 6 and accepted analysis methods.

502.3.3 Component Tradeoffs for Low-rise Dwellings and Apartments

The $U_o$ value for a particular component may be decreased, provided that the total heat loss or gain for the entire building envelope does not exceed the total resulting from conformance to the corresponding $U_o$ values specified in Table 5-1.

TABLE 5-1

COMPONENT REQUIREMENTS FOR LOWRISE RESIDENTIAL BUILDING

CONVERTING TO ELECTRIC SPACE HEAT

| COMPONENT | GROUP R DIVISION 3 ($U_o$ Value) | GROUP R DIVISION 1 ($U_o$ Value) |
|---|---|---|
| Roof/ceiling | .028 | .035 |
| Walls | .20 | .24 |
| Floors over unconditioned | | |
| Space-Enclosed | .08 | .08 |
| Exposed | .035 | .05 |
| Slab-on-grade floors | | |
| Unheated (R value) | 5.0 | 5.0 |
| Heated (R value) | 8.0 | 8.0 |

TABLES 5-2 through 5-9

(Reserved)

MEC CONVERSION EQUIVALENT CODE

EQ. 1

THERMAL TRANSMITTANCE

$$U = \frac{1}{1/f_o + R_1 + R_2 + \ldots R_n + 1/f_i} \quad \ldots\ldots\ldots\ldots \quad \text{EQUATION 1}$$

WHERE:

$U$ = the thermal transmittance of the assembly

$f_o$ = outside air film conductance,
$1/f_o = .17$ for all exterior surfaces

$f_I$ = inside air film conductance,
$1/f_i = .60$ for interior horizontal surfaces
$1/f_i = .68$ for interior vertical surfaces

$R$ = $\frac{1}{C} + \frac{X}{K}$ = measure of the resistance to the passage of heat from 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

MEC CONVERSION EQUIVALENT CODE

EQ. 2

OVERALL THERMAL TRANSMITTANCE: WALLS

$$U_o = \frac{U_w A_w + U_g A_g + U_d A_d \cdots}{A_o} \quad \ldots\ldots\ldots \quad \text{EQUATION 2}$$

WHERE:

$U_o$ = the overall thermal transmittance of the gross wall area

$A_o$ = the gross wall area of exterior walls

$U_w$ = the thermal transmittance of all elements of the opaque wall area

$A_w$ = the area of the opaque wall

$U_g$ = the thermal transmittance of the glazing area

$A_g$ = the glazing area, including sash

$U_d$ = the thermal transmittance of the door

$A_d$ = the door area

NOTE: Whre more than one type of wall, window, and/or door is used, the U and A terms for those items shall be expanded into subelements, as:
$U_{w1}A_{w1} + U_{w2}A_{w2} + U_{w3}A_{w3} + \ldots$ etc.

Calculations shall include the effects of all heat flow paths, such as framing members. Wood framing as a percent of opaque wall area is typically:

- 17 percent for 2-inch studs at 12" o.c.
- 15 percent for 2-inch studs at 16" o.c.
- 12 percent for 2-inch studs at 24" o.c.
- 20 percent for 3-inch studs at 16" o.c.

OVERALL THERMAL TRANSMITTANCE: ROOF/CEILING

$$U_o = \frac{U_f \times A_r}{A_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{EQUATION 3}$$

WHERE:

$U_o$ = the overall thermal transmittance of the gross opaque roof/ceiling area

$A_o$ = the gross opaque area of the roof/ceiling assembly

$U_r$ = the thermal transmittance of all elements of the opaque roof/ceiling area

NOTE: Where more than one type of roof/ceiling is used, the U x A term for that exposure shall be expanded into its subelements, as:

$(U_{r1} \times A_{r1}) + (U_{r2} \times A_{r2}) + (U_{r3} \times A_{r3})$ . . . etc.

Calculations shall include the effects of all heat flow paths, such as framing members. Wood framing as a percent of opaque roof/ceiling area is typically:

- 13 percent for 2-inch joists at 12" o.c.
- 10 percent for 2-inch joists at 16" o.c.
- 6 percent for 2-inch joists at 24" o.c.

MEC CONVERSION EQUIVALENT CODE

OVERALL THERMAL TRANSMITTANCE: FLOOR

$$U_o = \frac{(U_f \times A_f)}{A_o} \quad \text{EQUATION 4}$$

WHERE:

$U_o$ = the overall thermal transmittance of the gross floor over unconditioned space

$A_o$ = the gross floor area over an unconditioned floor assembly

$U_f$ = the thermal transmittance of all elements of the opaque floor area

$A_f$ = the gross floor area of the opaque floor assembly

NOTE: Where more than one type of floor assembly is used, the U x A for that exposure shall be expanded into subelements as:

$$(U_{f1} \times A_{f1}) + (U_{f2} \times A_{f2}) + \ldots \text{(etc.)}$$

Calculations shall include the effects of heat flow paths, such as framing members. Framing as a percent of floor area is typically:

- 13 percent for 2-inch joists at 12" o.c.
- 10 percent for 2-inch joists at 16" o.c.
- 6 percent for 2-inch joists at 24" o.c.
- 10 percent for 2-inch plank and 4-inch beams at 48" o.c.

OVERALL THERMAL TRANSMITTANCE: BUILDING

$UA_{op}$ equal to or less than $UA_o$ . . . . . . . . . . . . . . . . . EQUATION 5

WHERE:

$UA_{op}$ = the overall thermal transmittance of the proposed building's envelope calculated as the average of the component $U_o$ derived from Equations 2, 3, and 4 using the $U_o$ value for each building component proportionally.

$UA_{op}$ = $(U_{op1} \times A_1 + U_{op2} \times A_2 + \ldots U_{opn} \times A_n)$

$UA_o$ = the overall thermal transmittance of the building envelope of the standard design calculated as the average of the component $U_o$ derived from the $U_o$ values stated in Table 5-1.

$UA_o$ = $(U_{o1} \times A_1 + U_2 \times A_2 + \ldots U_{on} \times A_n)$

and

$U_{op1}$ = the thermal transmittance of building envelope component 1 derived using Equations 2, 3, or 4 for the proposed building.

$A_1$ = the area $ft^2$ of the building envelope $U_{op1}$.

$U_{op2}$ = the thermal transmittance of building envelope component 2 derived using Equations 2, 3, or 4 for the proposed building.

$A_2$ = the area $ft^2$ of building envelope component $U_{op2}$.

$U_{opn}$ = the thermal transmittance of building envelope component n derived using equations 2, 3, or 4 for the proposed building.

$A_n$ = the area $ft^2$ of building envelope component n.

$U_{o1}$ = the thermal transmittance of building envelope component 1, as stated in Table 5-1.

$A_1$ = the area of building envelope component 1 for the proposed building.

$U_{o2}$ = the thermal transmittance of building envelope component 2, as stated in Table 5-1.

$A_2$ = the area of building envelope component 2 for the proposed building.

$U_{on}$ = the thermal transmittance of building envelope component n as stated in Table 5-1.

$A_n$ = the area $ft^2$ of building envelope component n for the proposed building.

MEC CONVERSION EQUIVALENT CODE

HEAT STORAGE CAPACITY

$HS = D \times SH \times V$ . . . . . . . . . . . . . . . . . . . . . . . . . EQUATION 6

WHERE:

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

V = Volume of heat storage components.

D = Density of material inside the insulated shell of the building to a depth yielding a thermal resistance of R-1, except in the case of slab floors where only the slab itself is credited. Mass located in conditioned or unconditioned basements withut solar glazing shall not be counted. (lbs/cf).

SH = Specific heat of the material (Btu/bl/$^{o}$F).
The following quantities provide 10 Btu/$^{o}$F or heat storage capacity.

20 square feet of 1/2" gypsum board interior finish of interior walls and partitions.

40 square feet of 1/2" gypsum board on the interior or exterior walls.

1.5 square feet of 8-inch lightweight concrete masonry wall, insulated externally.

1.5 square feet of 4-inch nominal concrete slab floor with tile terrazzo, or plain finish.

## SECTION 503

## BUILDING MECHANICAL SYSTEMS--NON-RESIDENTIAL

503.1 (Reserved)

503.2 (Reserved)

503.3 (Reserved)

503.4 (Reserved)

503.5 (Reserved)

503.6 (Reserved)

503.7 (Reserved)

503.8 (Reserved)

503.9 Air-handling Duct Systems Insulation

Duct systems, or portions thereof, shall be insulated to provide a thermal resistance, excluding air films, of R-4 when not installed within conditioned space. A weatherproof barrier shall be provided to protect any exterior insulation. All ducts for mechanical cooling shall provide a vapor retarder with a drycup rating not greater than 0.05 perm.

EXCEPTIONS: Duct insulation is not required in the following cases:

1. When the heat gain and/or loss of the ducts, without insulation will not increase the annual energy requirements of the building.
2. Within HVAC equipment.
3. Exhaust air ducts.
4. Residential building mechanical systems exempt from this section.

5.3.10 (Reserved)

503.11 Piping Insulation

503.3.1 All exposed and readily accessible electrically heated hot water piping installed to service buildings and within buildings shall be thermally insulated in accordance with Table 5-10. For service water heating systems, see section 504.

EXCEPTIONS: Piping insulation is not required in the following cases:

1. When the heat gain and/or loss of the piping without insulation will not increase the annual energy requirements of the building.

2. Piping installed within HVAC equipment.

3. Piping at fluid temperatures between 55 and 100°F.

503.3.2 Additional insulation with vapor barriers shall be provided to prevent condensation.

EXCEPTION: Vapor barriers may be omitted when it can be demonstrated that condensation is not a problem.

TABLE 5-10

MINIMUM PIPE INSULATION

| Piping System Types | Fluid Temp Range (°F) | INSULATON THICKNESS IN INCHES FOR PIPE SIZES[2] Run-Outs 2"[1] | 1" and Less | 1.25" to 2" | 2.5" to 4" | 5" to 6" | 8" and Larger |
|---|---|---|---|---|---|---|---|
| Heating and Hot Water Steam and Hot Water | | | | | | | |
| High Pressure | 306-450 | 1.5 | 2.5 | 2.5 | 3.0 | 3.5 | 3.5 |
| Med. Pressure | 251-305 | 1.5 | 2.0 | 2.5 | 2.5 | 3.0 | 3.0 |
| Low Pressure | 201-250 | 1.0 | 1.5 | 1.5 | 2.0 | 2.0 | 2.0 |
| Low temp. | 120-200 | 0.5 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| Steam Condensate (for feed water) | Any | 1.0 | 1.0 | 1.5 | 2.0 | 2.0 | 2.0 |
| Cooling systems | | | | | | | |
| Chilled Water | 40-55 | 0.5 | 0.5 | 0.75 | 1.0 | 1.0 | 1.0 |
| Refrigerant or Brine | Below 40 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 |

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

2 For piping exposed to outdoor air, increase thickness by 0.5 inch.

SECTION 504

SERVICE WATER HEATING - RESIDENTIAL AND NON-RESIDENTIAL

504.1 Scope

The purpose of this section is to provide criteria for design and equipment selection that will produce energy savings when applied to service water heating.

504.2 Water Heaters and Storage Tanks

504.2.1 Performance Efficiency. All electric storage water heaters installed shall comply with ASHRAE Standard 90A-1980 and be so labeled or shall be insulated to a thermal resistance of 16 (R-16) where space allows. Additional insulation shall not be required if the water heater has been certified by the manufacturer to have a standby loss no greater than 2.8 watts per square foot of external area. All storage tanks shall be placed on an incompressible, non-combustible, insulated surface with a thermal resistance of at least 10 (R-10).

EXCEPTION: Where walls or other barriers prevent installation of R-16 insulation, electric water associated storage tanks shall be insulated to the maximum extent possible and violate no UL listing.

504.2.2 Insulation for Electric Hot Water Pipes. Pipe insulation shall follow the requirements specified in Section 503 and Table 5-10.

# SECTION 505

# ELECTRICAL POWER AND LIGHTING--NON-RESIDENTIAL

## 505.1 General

Electrical power and lighting systems shall be designed to conserve energy as provided herein.

## 505.2 Electrical Energy Consumption

In multi-family dwellings, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

EXCEPTION: Transient facilities such as hotels and college dormitories are exempt from this section.

## 505.3 Lighting Power Budget

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

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

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

### 505.3.1 Budget Development

The installed lighting wattage for the building project shall not exceed the budget level calculated in this section. The budget wattage level shall be the sum of the interior budget calculated in accordance with subsection 503.3.2 and the exterior budget calculated in accordance with subsection 503.3.4. Lighting wattage includes lamp and ballast wattage.

EXCEPTION: The budget level calculated in this section may be increased if it can be shown that the recommended illuminance values for lighting design specified in the Illuminating, Engineering Society (IES) 1981 "Lighting Handbook, Applications Volume" cannot be achieved with the unit power budgets permitted in section 505.3 when the most efficient equipment and lighting controls suitable for the specific task are used. Calculations for such special conditions shall be based on IES Unit Power Density or similar nationally recognized standards.

505.3.1.2 When insufficient information is known about the specific use of the building space (e.g. space function or size of retail tenants), the budget shall be based on the apparent intended use of the building space.

505.3.2 Building Interiors. The interior lighting budget shall be calculated by multiplying the gross floor area, in square feet, by the appropriate unit power budget, in watts per square foot, specified in Table 5-3.

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

EXCEPTION: Where the following automatic lighting controls are installed for calculation purposes, the installed lighting wattage may be reduced by the following percentages:

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

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

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

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

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

505.3.3 Exceptions to Building Interior Criteria. Lighting for the following applications shall be exempted from inclusion in the calculation of lighting power budgets:

- Stage lighting, entertainment, or audiovisual presentations where lighting is an essential technical element for the function performed.

- Lighting for medical and dental tasks.

- Lighting in areas specifically designed for visually handicapped people.

- For restaurant occupancies, lighting for kitchens and food preparation area.

- Power required for trickle-charging for battery-powered emergency lighting.

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

TABLE 5-3
LIGHTING POWER BUDGET[1]

| Occupancy Group | Occupancy Description | Lighting Power Budget[2] (Watts/sq ft) |
|---|---|---|
| A-1 | Assembly w/stage: occupancy of 100 or more | 1.1 |
| A-2 | Assembly w/stage: occupancy of less than 1000 | 1.1 |
| A-2.1 | Assembly w/o stage: occupancy of 300 or more other than B-2 and E | 1.1 |
| | Drinking and dining establishment | 1.85 |
| A-3 | Assembly w/o stage: occupancy of less than 300 other than B-2 and E | 1.1 |
| | Drinking and dining establishment | 1.85 |
| A-4 | Stadiums, reviewing stands and amusement park structures not included in A or B-1, B-2 and B-3 | 1.1 |
| B-1 | Gasoline and service stations: includes the office, waiting room and pump islands plus 5 feet on each side of the island | 2.0 |
| | Storage garages | 0.3 |
| B-2 | Office buildings, wholesale stores, municipal police and fire stations | 2.0 |
| | Retail stores and museums | |
| | - less than 100 square feet | 5.0 |
| | - 1000 to 6000 square feet | 4.0 |
| | - 6000 to 20,000 square feet | 3.0 |
| | - over 20,000 square feet | 2.0 |
| | Drinking and dining establishments: load of less than 50 | 1.85 |
| | Workshops using material not highly flammable or combustible | 2.0 |
| | Storage and warehouses | 0.7 |
| B-3 | Aircraft hangars | 0.7 |
| | Open parking garages | 0.3 |
| B-4 | Ice plants, power plants, pumping plants, cold storage and creameries | 1.0 |
| | Factories and work shops | 2.0 |
| | Storage | 0.7 |
| | Sales rooms | 2.0 |
| | Shipyard structures | 0.7 |
| E-1 | Schools and daycare centers | 2.0 |
| H-1 | Storage | 0.7 |
| | Handling | 2.0 |

continued

TABLE 5-3
LIGHTING POWER BUDGET[1]
(continued)

| Occupancy Group | Occupancy Description | Lighting Power Budget[2] (Watts/sq ft) |
|---|---|---|
| H-2 | Storage | 0.7 |
| | Handling, dry cleaning plants, paint stores | 2.0 |
| | Paint shops and spray painting rooms | 2.5 |
| H-3 | Warehouses | 0.7 |
| | Other | 2.0 |
| H-4 | Auto repair and body shops | 2.0 |
| | Paint spray booths | 5.0 |
| H-5 | Aircraft repair hangars | 2.0 |
| I-1 | Institutions | 2.0 |
| I-2 | Administrative support services | 2.0 |
| I-3 | Nursing areas | 2.0 |
| R-1<br>R-3 | Residential buildings | Exempt |

1 In case of an occupancy not specifically mentioned above, the lighting power budget in watts per square foot shall be determined by the Building Official based upon the budget for the most comparable occupancy specified.

2 Watts/ft$^2$ of room may be increased by two (2) percent per foot of height above 20 feet.

## SECTION 506

## ELECTRIC ENERGY AUDIT

### 506.1 Scope

The purpose of this section is to provide criteria for the electric energy analysis required by this code. The analysis shall apply to non-residential buildings converting to or expanding electric service for the purpose of electric space conditioning.

EXCEPTIONS: The electric energy analysis is not required for the following building occupancies:

- Low-rise residential buildings.
- Non-residential buildings for which new or enlarged service is for purposes other than electric space conditioning.
- Heat pump applications where the heat pump complies with the minimum performance standards set forth in the "Model Conservation Standards Equivalent Code Amendments to the Model Energy Code," Chapter 5.

### 506.2 Electric Energy Consumption Analysis

The electric energy analysis required shall follow Bonneville's "Technical Requirement for the Purchase of Energy Saving Program," and shall consist of the following analyses:

- existing consumption of electricity,
- modifications which will result in electric energy savings, and
- economic payback periods for those modifications.

506.2.1 Permanently installed electric systems. For permanently installed electric systems, the analysis of existing electricity consumption shall include wattage and approximate number of hours of annual operation including lighting, heating, air conditioning, ventilation, refrigeration, water and process heating.

506.2.2 Temporarily installed electric equipment. For all electric equipment which is not permanently installed for which the connected electric load is 5 kilowatts or greater, the analysis of existing electricity consumption shall include wattage and approximate number of hours of annual operation.

506.2.3 Building Survey. The information shall include a survey of construction details of the building which affect thermal performance, including, but not limited to insulation levels, glazing, infiltration and glazings *transmissivity.

506.2.4 Heating and Cooling Consumption. The analysis shall include an estimate of the annual heating and/or cooling electric consumption of the building.

506.3 Modifications Analysis

506.3.1 Maintenance and Modifications. The analysis of modifications which result in electric energy savings shall include but is not limited to:

- Preventive maintenance for equipment, including lubrication; mechanical system controls check; replacement of filters; and cleaning of all heat exchange surfaces and lighting fixtures;
- Repair and replacement of existing insulation;
- Electric systems operation timing;
- Shutoff of heating, ventilating, and air conditioning systems during unoccupied hours;
- Removing lamps and disconnecting ballast in areas where lighting can be reduced beyond the values required by the Lighting Power Budget.

506.3.2 Economic Analysis. The economic analysis of the electric energy saving modification shall show a pay-back period for each modification calculated by dividing the cost of the modification by the annual benefits. The costs shall include an estimated itemized cost of the modification, applicable taxes, and design and installation costs. The benefits shall include the monetary value of the annual kilowatt-hour savings, reduction in demand charges, and other identified benefits resulting from the modifications. The cost per kilowatt-hour and per kilowatt for computation purposes shall reflect all applicable costs and charges in the applicable local electric rate schedule at the time of computation. The measures installed shall be all those which meet the test of regional cost-effectiveness.

506.3.3 Alternative economic analysis. Alternative economic analyses, such as life-cycle costing or net present value, may be used provided that the above pay-back computation appears.

# CHAPTER 6

# BUILDING DESIGN BY PRESCRIPTIVE REQUIREMENTS APPROACH

## SECTION 601

## SCOPE

### 601.1 General

The provisions of this chapter are applicable to residential buildings--single family, duplex (Group R Division 3) and multi-family (Group R Division 1) occupancies.

## SECTION 602

## BUILDING ENVELOPE

The building envelope requirements of this chapter may be met by installing one of the prescriptive packages in Table 6-1. All components shall comply with the chosen specification over their entire surface, except as specified in this chapter.

### 602.1 Roof/ceilings

602.1.1 Ceilings below vented attics and vaulted ceilings shall be insulated to not less than the nominal R value specified in Table 6-1. Where architectural barriers preclude the installation of the specified R Value, roofs/ceilings must be insulated to the maximum extent possible.

602.1.2 Blown or poured loose fill insulation may be used in attic spaces where the slope of the roof is not less than 2-1/2 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. The surface of the installed blown or poured insulation shall be baffled. Baffles shall be of weather-resistant, rigid material capable of retaining the insulation.

602.1.3 Adequate cross ventilation shall be maintained above all ceiling insulation by providing both low and high vents or gable end vents. Ventilation openings shall not be blocked by insulation. (See Uniform Building Code Section 3205(c) and Section 502.2.2.1 of this code.)

### 602.2 Exterior walls above grade

Exterior walls above grade shall be insulated to the nominal values specified in Table 6-1 unless the walls have been previously insulated.

### 602.3 Exterior walls below grade

602.3.1 Exterior walls below grade adjacent to conditioned space, such as heated basements, shall be insulated to the nominal R value specified for below grade walls in Table 6-1.

602.3.2 Insulation shall extend from the top of the wall to the top of the footing or floor slab.

602.4 Slab-on-grade floors

602.4.1 Slab-on-grade floors shall be insulated along their perimeter to the nominal R value specified in Table 6-1. Where architectural barriers preclude the installation of the specified R value, slabs must be insulated to the maximum extent practicable.

602.5 Floors over unconditioned space

602.5.1 Floors over unconditioned space shall be insulated to the nominal R value in Table 6-1, unless the insulation requires major alteration of the existing building or unless installation with a nominal R 19 has been previously installed. Where the existing structure precludes the installation of prescribed in Table 6-1, insulation shall be installed to the maximum extent possible.

602.5.2 A ground cover of 6 mil opaque polyethylene or other approved material with a dry cup rating of not more than 1.0 perm shall be installed on the ground in crawl spaces when thermal insulation is installed with a minimum of 12 inches overlap at all joints and extend a minimum of 12 inches up the foundation walls.

602.5.3 Crawl spaces shall be ventilated by openings in exterior foundation walls. Such openings shall have a net area of not less than one square foot for each 150 square feet of *underfloor areas. Openings shall be located as close to corners as practical and shall provide cross ventilation. (See Uniform Building Code Section 2516(c)6.)

602.6 (Reserved)

602.7 Glazing Criteria

602.7.1 All glazing shall be at a minimum, double glazing. Insulating glass with at least 1/2 inch air space or approved storm sash shall be considered to comply.

602.7.2 Passive solar glazing. A passive solar building is required to have at least ten (10) percent of the building's gross floor area in glazing that meets the specifications of subsection 502.3.2 of this code.

## SECTION 603

(Reserved)

## SECTION 604

(Reserved)

## SECTION 605

## SERVICE WATER HEATING

Comply with Section 504.

TABLE 6-1

PRESCRIPTIVE REQUIREMENTS FOR ALL GROUP R OCCUPANCY RESIDENTIAL

BUILDINGS CONVERTING TO ELECTRIC SPACE HEAT

| | PACKAGE | | |
|---|---|---|---|
| | A | B | C |
| Component | Well Insulated | Passive Solar | Heat Pump[1] |
| BUILDING ENVELOPE | | | |
| Minimum Nominal R Value | | | |
| Roof/ceiling | R-38 | R-30 | R-30 |
| Above grade walls | R-11 | R-11 | R-11 |
| Below grade walls | R-11 | R-11 | R-11 |
| Slab-on-grade floors | R-5 | R-5 | R-5 |
| Floor over unconditioned space | R-30[2] | R-19 | R-19 |
| GLAZING | | | |
| Type | Double | Double | Double |

1 Heat Pump shall have a heating season performance factor (HSPF) of at least 6.8

2 Where joist size will not allow the installation of R-30, the floor over unconditioned space shall be insulated to the maximum extent possible.

CONVERSION STANDARD

EQUIVALENT CODE

to

CHAPTER 53

of the

UNIFORM BUILDING CODE

December 24, 1986

TABLE OF CONTENTS

CONTENTS

CHAPTER 53 ENERGY CONSERVATION IN BUILDINGS CONVERTING TO ELECTRIC SPACE CONDITIONING


SEC. 5301. General . . . . . . . . . . . . . . . . . . . . . . . . . 1

5301.(a) Purpose . . . . . . . . . . . . . . . . . . . . . . . . . 1
5301.(b) Design Method . . . . . . . . . . . . . . . . . . . . . . 1
5301.(c) Alterations and Repairs . . . . . . . . . . . . . . . . . 2
5301.(d) Change of Space Conditioning (Reserved) . . . . . . . . 2
5301.(e) Additions to Existing Buildings (Reserved) . . . . . . 2
5301.(f) Historic Buildings . . . . . . . . . . . . . . . . . . . 2
5301.(g) Change of Occupancy (Reserved) . . . . . . . . . . . . 2
5301.(h) Moved Buildings (Reserved) . . . . . . . . . . . . . . 2
5301.(i) Projects over 50,000 Square Feet in Conditioned Floor Area (Reserved) . . . . . . . . . . 2
5301.(j) Materials and Equipment . . . . . . . . . . . . . . . . 2
5301.(k) Plans and Specifications . . . . . . . . . . . . . . . . 2

SEC. 5302. Definitions . . . . . . . . . . . . . . . . . . . . . . . . . 3

SEC. 5303. Installation and Design Requirements . . . . . . . . . 9

5303.(a) General . . . . . . . . . . . . . . . . . . . . . . . . . 9
5303.(b) Insulation . . . . . . . . . . . . . . . . . . . . . . . 9
5303.(c) Moisture Control . . . . . . . . . . . . . . . . . . . . 9
5303.(d) Design Parameter . . . . . . . . . . . . . . . . . . . . 10

SEC. 5304. Building Design by Energy Budgets Method for Low-Rise Residential Dwellings . . . . . . . . 12

5304.(a) General . . . . . . . . . . . . . . . . . . . . . . . . . 12
5304.(b) Energy Budgets . . . . . . . . . . . . . . . . . . . . . 12
5304.(c) Comparable Design Basis . . . . . . . . . . . . . . . . 12
5304.(d) Calculation Procedure . . . . . . . . . . . . . . . . . 12
5304.(e) Standardized Input Values . . . . . . . . . . . . . . . 12

SEC. 5305. Building Design by Component Performance Method . . . . 14

5305.(a) General . . . . . . . . . . . . . . . . . . . . . . . . . 14
5305.(b) Building Envelope Requirements . . . . . . . . . . . . 14
5305.(c) Thermal Performance Criteria for Low-rise Dwellings and Apartment Houses . . . . . . . . . . . 14
5305.(d) Thermal Performance Criteria for Buildings Other than Low-rise Dwellings and Apartment Houses-Heating (Reserved) . . . . . . . . 17

5305.(e) Thermal Performance Criteria for Other than Low-rise Dwellings and Apartment Houses-Cooling (Reserved) . . . . . . . . . . . . . 17
5305.(f) Air Leakage in all Buildings (Reserved) . . . . . . . . 17
5305.(g) Building Mechanial Systems (Reserved) . . . . . . . . . 17
5305.(h) HVAC Equipment Performance Requirements (Reserved) . . . . . . . . . . . . . . . . . . . . 17
5305.(i) Transport Energy (Reserved) . . . . . . . . . . . . . . 17
5305.(j) Balancing (Reserved) . . . . . . . . . . . . . . . . 17
5305.(k) Cooling with Outdoor Air (Reserved) . . . . . . . . . . 17
5305.(l) Controls (Reserved) . . . . . . . . . . . . . . . . . . 17
5305.(m) Non-residential Air-handling Duct System Insulation . . . . . . . . . . . . . . . . . . . . 17
5305.(n) Piping Insulation . . . . . . . . . . . . . . . . . . . 17
5305.(o) Service Water Heating . . . . . . . . . . . . . . . . . 18
5305.(p) Electric Equipment (Reserved) . . . . . . . . . . . . . 18
5305.(q) Lighting Control (Reserved) . . . . . . . . . . . . . . 18
5305.(r) Lighting Power Budget . . . . . . . . . . . . . . . . . 18
5305.(s) Electric Energy Audit . . . . . . . . . . . . . . . . . 20

SEC. 5306 Building Design by Prescriptive Requirements Method . . . . . . . . . . . . . . . . 29

5306.(a) General . . . . . . . . . . . . . . . . . . . . . . . . 29
5306.(b) Building Envelope Requirements . . . . . . . . . . . . . 29
5306.(c) Air Leakage (Reserved) . . . . . . . . . . . . . . . . 31
5306.(d) Building Mechanical Systems (Reserved) . . . . . . . . 31
5306.(e) Service Hot Water Heating . . . . . . . . . . . . . . . 31

# CHAPTER 53

## ENERGY CONSERVATION IN BUILDINGS

## CONVERTING TO ELECTRIC SPACE CONDITIONING

### GENERAL

Sec. 5301. (a) Purpose. The provisions of this Chapter shall regulate residential buildings whose new or enlarged electric service is for electric space heat is converted from any other fuel. This Chapter shall regulate non-residential buildings or portions thereof whose new or enlarged electric service is for space conditioning. The requirements of this Chapter are intended to meet or exceed the applicable existing building codes and Federal regulations. In any case where a Federal, state or local code or regulation exceeds this Chapter's requirements with respect to securing more efficient use of electric energy, that code or regulation shall apply.

Authority for the provisions of this code comes from the Northwest Power Planning Council's "Northwest Conservation and Electric Power Plan," 1986, Volume One, page 9-9, Section 3, "Residential and Commercial Buildings Converting to Electric Space Conditioning."

EXCEPTIONS: 1. In lieu of the specific provisions of this Chapter, a package of efficiency measures which can be shown to achieve savings comparable to those which would be achieved by incorporating all efficiency improvements up to the regionally cost-effective level may be substituted.

2. Temporary services, construction services, and replacement services which do not increase the amperage capacity of the incoming service are not subject to the requirements of this code.

(b) Design Method. 1. All residental buildings may satisfy the space heating and hot water heating requirements of this Chapter by one of up to three methods: Energy Budget (Section 5304), Component Performance (Section 5303) or Prescriptive Requirements (Section 5306).

2. All non-residential buildings may satisfy the requirements of this Chapter by compliance with:

A. Service water heating minimums,
B. Piping and duct insulation minimums,
C. Lighting power budgets, and
D. Submission of an electric energy audit to the servicing utility or local government.

EXCEPTION: Non-residential customers whose new or enlarged service connection is for purposes other than electric space conditioning need not submit the electric energy audit or incorporate efficiency upgrades.

(c) Alterations and Repairs. Where the structural elements of the roof/ceiling, wall, or floor area are not being replaced, alterations and repairs shall be deemed to comply with the opaque envelope standard if all existing framing cavities are filled to their full depth with batt insulation or insulation of an equivalent nominal R-value, where necessary, maintaining space for ventilation.

(d) Changes of Space Conditioning. (Reserved)

(e) Additions to Existing Buildings. (Reserved)

(f) Historic Buildings. The Building Official may modify the specific requirements of this Chapter only to the extent necessary to preserve those significant elements of buildings and structures designated by a Federal, state or local govenment body as landmarks.

(g) Change of Occupancy. (Reserved)

(h) Moved Buildings. (Reserved)

(i) Projects over 50,000 Square Feet in Conditioned Floor Area. (Reserved)

(j) Materials and Equipment.

1. Identification. Materials and equipment shall be identified to show compliance with this Chapter.

2. Maintenance Information. Required regular maintenance actions shall be clearly stated on a visible label. Such label may be limited to identifying the operationand maintenance manual for that particular product.

(k) Plans and Specifications. The existing building envelope comonent R-values shall be specified and may be verified by the Building Official.

Chapter 53 Conversion Equivalent Code

DEFINITIONS

Sec. 5302. The following terms are define for use within this Chapter:

ACCEPTED ANALYSIS METHODS. Heating/cooling and lighting load calculations approved by the Building Official and performed in accordance with the most current procedures developed by a nationally recognized professional organization (such as ASHRAE).

ACCESSIBLE. (As applied to equipment) Admitting close approach not guarded by locked doors, elevation or other effective means.

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. (See MANUAL.)

BELOW GRADE WALL. A wall or section thereof which extends no more than three (3) feet above the finished grade at any point.

BRITISH THERMAL UNIT (Btu). The amount of heat required to raise the temperature of one pound of water by one Fahrenheit degree at 60°F.

BUILDING ENVELOPE. The elements of a building which enclose conditioned spaces and conditioned air supply systems.

BUILDING OFFICIAL. The official authorized to act in behalf of the responsible govenment agency for the enforcement of this Chapter.

C VALUE (THERMAL CONDUCTANCE). The thermal transmission per hour through unit area of a particular body or assembly having defined surfaces when the unit average temperature is established between surfaces (Btu/hr/$ft^2$/°F).

COMPONENT PERFORMANCE METHOD. Compliance with this Chapter by demonstrating that the maximum steady state coefficient of heat transfer as specified in Btu/°F/$ft^2$ for building components: walls (including all components of the gross area, such as windows and doors), roof/ceilings, floors over unconditioned space, slab-on-grade floors, and space exposed to outside air does not exceed the values in Section 5304.

CONDITIONED FLOOR AREA. The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

CONDITIONED SPACE. Space within a building which is five (5) feet or more in height from finished floor to finished ceiling and which is conditioned directly or indirectly by an energy-using system capable of maintaining a temperature of 50°F or higher for heating and/or 85°F or below for cooling. It shall also include spaces with humidification or dehumidification means so as to be capable of maintaining a space condition falling within the comfort zone set forth in Standard RS-4. Enclosed corridors between conditioned spaces shall be considered as conditioned space.

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 on 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.

DWELLING UNIT. (See Uniform Building Code.)

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

ENERGY. Electricity shall be considered as the primary energy form for space conditioning in buildings using multiple fuels where the estimated electric energy requirements for space conditioning are greater than the estimated annual non-electric space conditioning requirements.

ENERGY BUDGETS METHOD. Compliance with this Chapter by demonstrating that the structure is designed as efficiently as a comparable one conforming with Section 5304.

EXTERIOR WALL. A wall, or section thereof, which is exposed to an exterior ambient condition and encloses conditioned space.

FLOOR OVER UNCONDITIONED SPACE (ENCLOSED). A floor which separates a conditioned space from an unconditioned space which if buffered from ambient weather conditions including vented crawl spaces and unconditioned basements or other similar spaces.

FLOOR OVER UNCONDITIONED SPACE (EXPOSED). A floor which separates a conditioned space from an unconditioned space exposed to outdoor weather conditions including open parking garages and enclosed garages which are mechanically ventilated.

GLAZING. All areas including frames in the shell of a conditioned space that let in natural light, including windows, clerestories, skylights, sliding glass doors, glass brick walls, and the glazed portions of doors.

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

GROSS FLOOR AREA. The sum of the area of the several floors of a building, including basements, cellars, mezzanine and intermediate floored tiers and penthouses of headroom height, measured from the interior faces of exterior walls (see Section 407, Uniform Building Code), but excluding:

Covered walkways, open roofed-over areas, porches and similar spaces.
Pipe trenches, exterior terraces or steps, chimneys, roof overhangs and similar features.

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

GROSS EXTERIOR 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, and door areas. The gross area of exterior walls consists of all opaque walls areas, including foundation walls, 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 conditioned space including interstitial areas between two such spaces.

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

HEATED SPACE. Space within a building which is provided with a positive heat supply. Finished living space within a basement or registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space.

HEATING SEASON PERFORMANCE FACTOR (HSPF). The total heating output (in Btu) of a heat pump during its normal annual usage period for heating divided by the total (watt hour) electric power input during the same period, as determined by test procedures consistent with the U.S. Department of Energy "Test Procedure for Central Air Conditioners, Including Heat Pumps" published in the December 27, 1979, Federal Register, Vol. 44, No. 24, IOCFR. 430. When specified in Btu per watt hour an HSPF of 6.826 is equivalent to an HSPF of 2.0 watt hour per watt hour.

HVAC. Heating, ventilating, and air conditioning.

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

LOW-RISE BUILDING. A building not exceeding three stories of conditioned space in height.

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

MANUAL. Capable of being operated by personal intervention. (See AUTOMATIC.)

MAY. Where "may" is used in a specific provision, that provision is permissible.

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

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

OPERABLE WINDOW INSULATION. Movable window covers of insulating material which have means to create an edge fit better than a loose fit (i.e., interlocking edge, cushion seal, mechanical, or magnetic seal) and with a minimum thermal resistance of R-5.

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

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

POWER. The rate at which electric energy is transmitted; in customary units, measured in watts (W) or British thermal units per hour (Btu/hr).

PERSCRIPTIVE REQUIREMENTS METHOD. Compliance with this Chapter through installation of specified minimum insulation levels and infiltration control measures set forth in Section 5306.

ROOF/CEILING ASSEMBLY. A roof/ceiling assembly shall be considered as all components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to an exterior ambient and encloses conditioned space. This does not include elements which are separated from a conditioned space by a vented air space.

The gross area of a roof/ceiling assembly consists of the total interior surface of such assembly, including skylights exposed to the conditioned space.

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

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

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

SHOULD. Not mandatory but desirable as good practice.

SKYLIGHT. A glazed opening in a roof/ceiling assembly, consisting of a supporting structure with glass, plastic or similar material tilted up from the horizontal less than sixty (60) degrees.

SLAB-ON-GRADE FLOOR. Any slab poured in contact with the ground and for which the top of the finished slab is less than 24 inches below the final elevation of the nearest exterior grade.

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

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

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

THERMAL CONDUCTANCE (C). The thermal transmission in unit time through unit average temperature is established between surfaced (Btu/hr/ft$^2$/$^o$F).

THERMAL RESISTANCE (R). The reciprocal of thermal transmission (Btu/hr/ft$^2$/$^o$F).

THERMAL TRANSMITTANCE, OVERALL ($U_o$). The overall coefficient of the heat transmission (air-to-air) due only to the difference in indoor and outdoor air temperatures of a gross are of the exterior building envelope (Btu/hr/ft$^2$/$^o$F). The $U_o$ value applies to the combined effect of the time rate of heat flows through the various parallel paths, such as window, doors and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/ceiling.

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

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

Chapter 53 Conversion Equivalent Code

U VALUE (THERMAL TRANSMITTANCE, OVERALL). The overall (average) heat transmission of a gross area of the exterior building's envelope ($Btu/hr/ft^2 {}^\circ F$). The $U_o$ value applies to the combined effect of the time rate of heat flows through the various parallel paths, such as windows, doors and opaque areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/ceiling.

VAPOR RETARDER. A layer of low moisture transmissivity material (not more than 1.0 perm dry cup) which is placed over the warm side (in winter) of insulation, over the exterior of below grade walls, and under floors as ground cover to limit the diffusion of water and water vapor through exterior walls, ceilings and floors. The layer may or may not be an integral part of the insulation and may or may not be continuous.

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

UTILITY REPRESENTATIVE. The agent authorized to act in behalf of the responsible utility.

INSTALLATION AND DESIGN REQUIREMENTS

Sec. 5303. (a) General. This section establishes installation requirements and sets forth design parameters for residential building envelopes converting to electric space heating and non-residential buildings or portions thereof converting for electric space conditioning.

A building that is designed to be both heated and cooled shall meet the more stringent of the heating or cooling requirements of this Chapter. Heating and cooling design loads shall be calculated in accordance with accepted analysis methods.

(b) Insulation. See Sec. 1713, 1717 and 3204.

1. Clearances. See Sec. 3703.

2. Installation. Insulation shall extend full thickness over entire area and shall be cut and fit around obstructions and adjoining insulation. Integrity of vapor retarders shall be maintained by taping and sealing joints, ruptures and edges of units adjoining other surfaces. Batt insulation units shall be secured by friction fit, or with adhesive or mechanical fasteners. Loose fill insulation installed by pouring or by machine-blowing shall be leveled in horizontal applications to a uniform thickness. Thermal insulation shall not be installed in a manner that would obstruct openings for structural ventilation. Permanent baffling of vent openings shall be provided to retain the insulation. Attic access panels separating conditioned and unconditioned spaces shall be weatherstripped, and insulated to a thermal resistance (R-value) equal to the surrounding envelope component.

EXCEPTION: Ceiling insulation in low-rise dwellings and apartments may be tapered or compressed at the perimeter to permit proper venting.

3. Slab-on-grade floors. Perimeter insulation shall extend downward from the top of the slab to the design frost line or a minimum of 24 inches whichever is greater. If the depth of the footing is less than 24 inches, then the insulation shall extend downward to the bottom of the slab or to the base of the foundation footing. Insulation shall be of an approved type.

EXCEPTION: For monolithic slabs, insulation shall extend downward to the bottom of the thickened edge.

(c) Moisture Control. To insure the effectiveness of insulation materials and reduce the hazard of decay to organic materials and other degradation due to condensation within the sturcture, moisture control and/or structural ventilation measures shall be included in all buildings.

1. Vapor Retarder. Where a vapor retarder is specified, it shall be installed facing the conditioned space.

EXCEPTION: Vapor retarders may be omitted when it can be demonstrated that condensation will not occur.

Rips and punctures in the vapor retarder shall be patched and sealed with vapor retardant material.

Exterior walls of new buildings shall have a vapor retarder when thermal insulation is installed. The vapor retarder shall have a 1.0 perm dry cup rating or less. The vapor retarder need not be an integral part of the insulation material. Flanges of faced insulation batts and framing members or the potential for moisture transfer due to infiltration minimized in some other approved manner.

All exterior ceilings shall have a vapor retarder with a 0.5 per dry cup rating or less when thermal insulation is installed. Where ceilings are plank and beam construction exposed to the conditioned space, the vapor retarder shall be placed on top of the planking, and the wall/ceiling joints shall be sealed with caulking or sealant. Flanges of faces insulation batts shall be lapped at framing members or the potential for moisture due to infiltration minimized in some other approved manner.

EXCEPTION: When insulation is installed and ventilation is provided as specified in Section 3205 (c) of the Uniform Building Code a vapor retarder need not be installed.

Floors shall have a vapor retarder installed according to manufacturer's specifications and have a 1.0 perm dry cup rating or less when thermal insulation is installed. The vapor retarder need not be an integral part of the insulation material.

2. Ground Cover. A ground cover shall be installed on the ground in crawl spaces when thermal insulation is installed. The ground cover shall be 6 mil opaque polyethylene or other material approved by the Building Official or utility representative with a 1.0 perm dry cup or less rating.

3. Attic and Crawl Space Ventilation. See Section 3205 and 5306(b).

(d) Design Parameter. 1. Exterior design temperatures. The heating or cooling design temperatures shall be selected from Chapter 24 of the 1985 Edition of the ASHRAE Handbook of Fundamentals. For locations not listed therein, other temperatures may be used as determined by the Building Official. Winter design temperatures shall be selected from the 97.5% column for all occupancies. Summer design dry-bulb and wet-bulb temperatures shall be selected from the 2.5% column.

2. Interior design temperatures. Interior design temperature for non-residential buildings shall be 70°F for heating and 78°F for cooling.

EXCEPTION: Other design temperatures may be used for equipment selection if they result in lower electric energy use as determined by accepted engineering practice.

3. Heating and Cooling Degree Days. The heating and cooling degree days shall be selected from the 1985 Edition of the ASHRAE Handbook of Fundamentals. For locations not listed therein, other sources of heating and cooling degree day data may be used provided such sources are approved by the Building Official or utility representative.

4. U Values (Thermal Transmittance).

A. Component U Values (coefficients of heat transfer) for opaque areas shall be taken or developed from Chapter 23 and Chapter 25 of the ASHRAE 1985 Handbook of Fundamentals and shall include appropriate adjustments for framing. Seasonal average conditions for wind speed shall be assumed to be 7.5 mph for calculation of outside air film coefficients and heat transfer rates through buffered spaces such as attics and vented crawl spaces.

B. Double glazing shall have a dead air space between panes of not less than 1/2 inch. Approved storm sash shall be considered to comply with this code.

BUILDING DESIGN BY ENERGY BUDGETS METHOD FOR LOW-r(R)ISE RESIDENTIAL DWELLINGS

Sec. 5304. (a) General. This section establishes design criteria in terms of total electric energy used by low-rise residential buildings and apartment houses before converting to electricity for space heating.

(b) Energy Budgets. Buildings designed in accordance with this section shall be deemed to comply with this Chapter if the calculated annual electric space heating energy consumption is not greater than a similar building (the "standard design") whose enclosure elements and energy consuming systems are designed in accordance with Section 5306 for the applicable building type and which conform to the applicable provisions of Section 5305 of this Chapter.

(c) Comparable Design Basis. The standard design, conforming to Section 5305, and the proposed design shall be designed on a common basis. The comparison of total electric energy usage shall be expressed in Btu input per square foot of gross floor area for the standard design and the proposed design at the building site. Comparison of similar elements, systems, or components shall be expressed in dimensions or terms accepted by standard engineering practice.

(d) Calculation Procedure. The calculation procedure shall cover the following items:

1. Design Parameters as shown in Section 5303 and this Section.

2. Climate data. Typical meteorological years (TMY) for closest appropriate site or as approved.

3. Building data. Orientation, size, shape, mass, and heat transfer characteristics.

(d) Standardized Input Values. The following standardized input values shall be used in calculating annual space heating budgets:

| | |
|---|---|
| 1. THERMOSTAT SET POINT: | Value |
| Heating | 65°F |
| Cooling | 78°F |
| Night set back | None |
| 2. INTERNAL GAINS: | |
| Internal gains from lights appliances and occupants (per dwelling unit) | 3000 Btu/°F or 72,000 Btu/day |

3. SOLAR ENERGY REQUIREMENTS:

| | |
|---|---|
| Minimum heat storage capacity available typical frame construction | 3 Btu/°F per sq.ft. of gross floor area |
| Site shading | Actual solar shading |

4. CLIMATE:

| | |
|---|---|
| Weather data | Typical meteorological year (TMY) or other appropriate site as approved |
| Heating season average wind speed | 7.5 mph (outside) |

5. INFILTRATION. Infiltration level used in the proposed design shall be consistent with the infiltration level used in the standard design or the designer shall provide documentation for alternate assumptions.

6. HEAT PUMP REQUIREMENTS. When electrically driven heat pumps using depletable energy sources are employed to provide all or part of the heat for the alternate design, the standard design shall also assume that an electrically driven heat pump having at least the same capacity as that used in the alternate design.

The heating season performance factor (HSPF) for heat pumps installed in low-rise residential structures shall be calculated using procedures consistent with Section 5.2 of the U.S. Department of Energy Test Procedure for Central Air Conditioners, including heat pumps published in the December 27, 1979 Federal Register Vol. 44, No. 24.10 CFR 430. The proposed building's overall thermal performance value (Btu/°F) and the standardized input assumptions specified in Section 5304 shall be used to model the heat pump HSPF.

Chapter 53 Conversion Equivalent Code

BUILDING DESIGN BY COMPONENT PERFORMANCE METHOD

Sec. 5305. (a) General.

This section established design criteria in terms of the thermal performance of the various components of a residential building before the building shall be converted for electric space heat. These criteria apply to all buildings except those exempt under Section 5301 or those conforming to the requirements of Section 5304 or Section 5306 of this Chapter. Buildings that are positively heated or cooled shall provide the required performance of their various components and systems.

Residential buildings being converted to electic space heat shall follow the requirements contained in Section 5305 (a), (b), and (c) of this Chapter and shall meet the overall thermal performance requirements specified therein.

Non-residential buildings for which new or enlarged electric service connections are requested shall follow the reqirements in Section 5305 (m), (n), (o), and (r) of this Chapter.

(b) Building Envelope Requirements. 1. The stated $U_o$ of any one element of a building, such as roof/ceiling, wall, or floor, may be increased and the $U_o$ 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 with the stated $U_o$ in Tabel 53-A. Equation 53-5 shall be used to determine conformance.

EXCEPTION: For slab-on-grade floors and below grade walls enclosing conditioned spaces the R value shall not be less than specified in Table 53-A.

2. Where return air plenums are employed, the roof/ceiling elements shall, for thermal transmittance purposes, not include the ceiling system or the plenum space; and for gross area purposes, be based upon the exposed plenum surface.

3. The design may take into consideration the thermal mass of building components when approved by the Building Official.

4. General insulation and vapor retarders shall be installed in accordance with Section 5303 of this Chapter.

(c) Thermal Performance Criteria for Low-rise Dwellings and Apartment Houses. 1. General Requirements. A. Exterior Walls: The overall thermal transmittance value ($U_o$) of the gross wall area of exterior walls shall not exceed the value given in Table 53-A, unless the overall thermal transmittance value ($U_o$) of the entire building envelope is equal to or less than that resulting from conformance with the stated ($U_o$) for all envelope surfaces.

Equations 53-1 and 53-3 shall be used to determine acceptable combinations to meet the $U_o$ specified for exterior walls. Equations 53-5 shall be used to determine conformance to the total building envelope.

B. Roof/Ceiling: The overall thermal transmittance value ($U_o$) of the gross ceiling area of the roof/ceiling assembly shall not exceed the value given in Table 53-A, transmittance value ($U_o$) of the entire building envelope is equal to or less than that resulting from conformance with the stated $U_o$ for all envelope surfaces. Equations 53-1 and 53-3 shall be used to determine acceptable combinations to meet the $U_o$ specified for roof/ceiling assemblies. Equation 53-5 shall be used to determine conformance for the total building envelope.

C. Floors Over Unconditioned Spaces: The overall thermal transmittance value ($U_o$) for floors over unconditioned spaced exposed to outside air such as floors over overhangs, shall not exceed the value given in Table 53-A, unless the overall thermal transmittance value ($U_o$) of the entire building envelope is equal to or less than that resulting from conformance with the stated $U_o$ for all envelope surfaces. The overall thermal transmittance value ($U_o$) for all other floors over unconditioned enclosed spaces such as vented crawl spaces, garages, and unheated basements, shall not exceed the value given in Table 53-A, unless the overall thermal transmittance value ($U_o$) of the entire building envelope is equal to or less than that resulting from conformance with the stated $U_o$ for all envelope surfaces. Equations 53-1 and 53-4 shall be used to determine acceptable combinations to meet the $U_o$ for floors over unconditioned spaces exposed to outside air or over unconditioned exposed spaces. Equation 53-5 shall be used to determine conformance for the building envelope.

EXCEPTIONS: (a) Floor insulation over unconditioned enclosed spaces may be reduced if the foundation walls are insulated such that the total thermal resistance (R value) of the installed insulation is not less than specified for floors in Table 53-A, and all foundation vents are equipped with tight fitting louvers.

(b) Floor insulation over unheated basements may be omitted if the entire basement wall is insulated to the levels specified for below grade walls in Table 53-A.

D. Slab-On-Grade Floors: For slab-on-grade floors, the thermal resistance value (R) of the insulation around the perimeter of the floor shall not be less than the value given in Table 53-A. The insulation shall extend downward from the top of the slab to the design frost line or a minimum distance of 24 inches whichever is greater. If the depth of the footing is less than 24 inches, then the insulation shall extend downward to the bottom of the slab or to the base of the foundation footing. Insulation shall be of a material approved for this use.

EXCEPTION: For monolithic slabs the insulation shall extend downward from the top of the slab to the bottom of the thickened edge.

E. Below grade walls surrounding conditioned spaces: Below grade walls surrounding conditioned spaces, such as heated basements, shall be insulated to a thermal resistance (R) value not less than the value given in Table 53-A for slab-on-grade floors, heated.

2. Exemption for Passive Solar Features. Subject to the following limitations, newly added glazing or mass- or water-wall areas in low-rise dwellings which qualify by meeting all of the criteria below may be assigned a U value of 0.00 for use in Equations 53-2 and 53-5.

A. The glazing area shall be oriented within 45 degrees of true south with a maximum of 60 percent between 31 and 45 degrees of true south.

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

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

D. Documentation in the form of a sun chart, photograph or other evidence, demonstrates that the glazing area oriented within 30 degrees of true south must receive direct solar exposure for at least 3 hours between 10 a.m. and 2 p.m. solar time on January 21st and March 21st.

E. Documentation in the form of a sun chart, photograph or other evidence demonstrates that the glazing area oriented between 31 and 45 degrees east or west of true south must not be shade for at least 2 hours between 9 a.m. and 12 noon standard time if east of south, and 12 noon and 3 p.m. standard time if west of south on January 21st and March 21st.

F. The building or addition shall contain a heat storage capacity equivalent to at least 20 Btu/°F for each square foot of solar glazing when the qualifying area is between eight (8) and fourteen (14) percent of the gross habitable conditioned floor area of the building and at least 45 Btu/°F for each square foot of solar glazing when the qualifying area exceeds fourteen (14) percent of the gross conditioned floor area of the building. This heat storage capacity shall be 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. If the storage medium is not within the space containing the qualifying glazing, an acceptable natural or mechanical means of transferring the heat to the heat storage medium shall be provided. Where a mass- or water-wall is located immediately behind the glazing, the mass- or water-wall shall be considered as having an acceptable natural means of transferring the heat to other heat storage capacity within that space. Heat storage capacity shall be calculated using Equation 53-6 and accepted analysis methods.

(d) Thermal Performance Criteria for Buildings Other than Low-rise Dwellings and Apartment Houses - Heating. (Reserved)

(e) Thermal Performance Criteria for Other than Low-Rise Dwellings and Apartment Houses - Cooling. (Reserved)

(f) Air Leakage in All Buildings. (Reserved)

(g) Building Mechanical Systems. (Reserved)

(h) HVAC Equipment Performance Requirements. (Reserved)

(i) Transport Energy. (Reserved)

(j) Balancing. (Reserved)

(k) Cooling with Outdoor Air. (Reserved)

(l) Controls. (Reserved)

(m) Non-residential Air-handling Duct Systems Insulation. The following covers duct systems.

1. Insulation. Ducts, plenums, and enclosures in or on buildings shall be thermally insulated as follows:

A. Duct systems, or portions thereof, shall be insulated to provide a thermal resistance of R-5 when not installed within conditioned space and R-4 in all other cases. A weatherproof barrier shall be provided to protect any exterior insulation. All ducts for mechanical cooling shall provide a vapor retarder with a drycup rating not greater than 0.05 perm.

EXCEPTIONS: Duct insulation is not required in the following cases:

1. Within HVAC equipment.
2. Exhaust air ducts.
3. When the heat gain and/or loss of the ducts, without insulation will not increase the annual energy requirements of the building.

(n) Piping Insulation. All exposed and readily accessible electrically heated hot water piping shall be thermally insulated as set forth in Table 53-L.

EXCEPTIONS: Piping insulation is not required in the following cases:

1. Piping installed within HVAC equipment.
2. Piping at fluid temperatures between 55 and 100°F.
3. When the heat gain an/or loss of the piping without insulation will not increase the annual energy requirements of the building.

1. Insulation thickness. Thicknesses in Table 53-L are based on insulation having thermal resistivity in the range of 4.0 to 4.6 Btu/hr/ft$^2$/$^o$F. Minimum insulation thicknesses for materials having an R value greater than 4.6, or less than 4.0, shall be revised proportionately according to the following equations.

A. For materials with thermal resistivity greater than 4.6, the minimum insulation thickness may be reduced as follows:

$$\text{New Minimum Thickness} = \frac{4.6 \times \text{Table 53-L Thickness}}{\text{Actual R}}$$

B. For materials with thermal resistivity less than 4.0, the minimum insulation thickness shall be increased as follows:

$$\text{New Minimum Thickness} = \frac{4.0 \times \text{Table 53-L Thickness}}{\text{Actual R}}$$

2. Insulation and vapor retarders. Additional insulation and/or vapor retarders shall be provided to control condensation on the surface of insulation on piping with temperatures below ambient.

(o) Service Water Heating. 1. Electric water heaters. Residential electric hot water heaters shall be insulated with a thermal resistance of 16 (R-16). All automatic, electric storage water heaters having a storage capacity greater than 120 gallons or an input rate greater than 12 kw shall have all storage tank top and side surfaces insulated to at least R-16, or have a standby loss rate not exceeding 2.8W/ft$^2$ of external tank surface area when tested in accordance with Section 4.3.1 or ANSI C 72.1-72 Household Automatic Electric Storage Type Water Heaters.

EXCEPTION: Where walls or other barriers prevent installation of R-16 insulation, electric water associated storage tanks shall be insulated to the maximum extent possible.

2. Storage Tanks. All residential and non-residential storage tanks shall be placed on an incompressible non-combustible, insulated surface with a thermal resistance of at least 10 (R-10).

(p) Electric Equipment. (Reserved)

(q) Lighting Control. (Reserved)

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

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

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

1. Budget Development

The installed lighting wattage for the building project shall not exceed the budget level calculated in this section. The budget wattage level shall be the sum of the interior budget calculated in accordance with subsection 503.3.2 and the exterior budget calculated in accordance with subsection 503.3.4. Lighting wattage includes lamp and ballast wattage.

EXCEPTION: The budget level calculated in this section may be increased if it can be shown that the recommended illuminance values for lighting design specified in the Illuminating, Engineering Society (IES) 1981 "Lighting Handbook, Applications Volume" cannot be achieved with the unit power budgets permitted in section 505.3 when the most efficient equipment and lighting controls suitable for the specific task are used. Calculations for such special conditions shall be based on IES Unit Power Density or similar nationally recognized standards.

2. Building Interiors. The interior lighting budget shall be calculated by multiplying the gross floor area, in square feet, by the appropriate unit power budget, in watts per square foot; specified in Table 53-N.

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

EXCEPTION: Where the following automatic lighting controls are installed for calculation purposes, the installed lighting wattage may be reduced by the following percentages:

A. For occupant-sensing devices, energy savings of 30 percent shall be allowed for any single space up to 400 square feet and enclosed by ceiling height partitions; classrooms, conference rooms, computer rooms, storage areas, corridors, or waiting rooms.

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

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

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

2. Exceptions to Building Interior Criteria. Lighting for the following applications shall be exempted from inclusion in the calculation of lighting power budgets:

A. Stage lighting, entertainment, or audiovisual presentations where lighting is an essential technical element for the function performed.

B. Lighting for medical and dental tasks.

C. Lighting in areas specifically designed for visually handicapped people.

D. For restaurant occupancies, lighting for kitchens and food preparation area.

E. Power required for trickle-charging for battery-powered emergency lighting.

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

(s) Electric Energy Audit. The purpose of this section is to provide criteria for the electric energy analysis required by this code. The analysis shall apply to non-residential buildings converting to or expanding electric service for the purpose of electric space conditioning.

EXCEPTIONS: The electric energy analysis is not required for the following building occupancies:

1. Low-rise residential buildings.

2. Non-residential buildings for which new or enlarged service is for purposes other than electric space conditioning.

3. Heat pump applications where the heat pump complies with the minimum performance standards set forth in the "Model Conservation Standards Equivalent Code Amendments to the Model Energy Code," Chapter 5.

A. Electric Energy Consumption Analysis. The electric energy analysis required shall follow Bonneville's "Technical Requirement for the Purchase of Energy Saving Program," and shall consist of the following analyses:

(1) existing consumption of electricity,
(2) modifictions which will result in electric energy savings, and
(3) economic payback periods for those modifications.

B. Permanently installed electric systems. For permanently installed electric systems, the analysis of existing electricity consumption shall include wattage and approximate number of hours of annual operation including lighting, heating, air conditioning, ventilation, refrigeration, water and process heating.

C. Temporarily installed electric equipment. For all electric equipment which is not permanently installed for which the connected electric load is 5 kilowatts or greater, the analysis of existing electricity consumption shall include wattage and approximate number of hours of annual operation.

D. Building Survey. The information shall include a survey of construction details of the building which affect thermal performance, including, but not limited to insulation levels, glazing, infiltration and glazings transmissivity.

E. Heating and Cooling Consumption. The analysis shall include an estimate of the annual heating and/or cooling electric consumption of the building.

F. Modifications Analysis. (1) Maintenance and Modifications. The analysis of modifications which result in electric energy savings shall include but is not limited to:

i. Preventive maintenance for equipment, including lubrication; mechanical system controls check; replacement of filters; and cleaning of all heat exchange surfaces and lighting fixtures;

ii. Repair and replacement of existing insulation;

iii. Electric systems operation timing;

iv. Shutoff of heating, ventilating, and air conditioning systems during unoccupied hours;

v. Removing lamps and disconnecting ballast in areas where lighting can be reduced beyond the values required by the Lighting Power Budget.

G. Economic Analysis. The economic analysis of the electric energy saving modification shall show a pay-back period for each modification calculated by dividing the cost of the modification by the annual benefits. The costs shall include an estimated itemized cost of the modification, applicable taxes, and design and installation costs. The benefits shall include the monetary value of the annual kilowatt-hour savings, reduction in demand charges, and other identified benefits resulting from the modifications. The cost per kilowatt-hour and per kilowatt for computation purposes shall reflect all applicable costs and charges in the applicable local electric rate schedule at the time of computation. The package of measures installed shall be all those which meet the test of regional cost-effectiveness.

H. Alternative economic analysis. Alternative economic analyses, such as life-cycle costing or net present value, may be used provided that the above pay-back computation appears.

## THERMAL TRANSMITTANCE

$$U = \frac{1}{\frac{1}{f_o} + R_1 + R_2 + \dots R_n + \frac{1}{f_i}}$$ . . . . . . . . . . . . . EQUATION (53-1)

WHERE:

- $U$ = the thermal transmittance of the assembly
- $f_o$ = outside air film conductance, $\frac{1}{f_o}$ = .17 for all exterior surfaces
- $f_I$ = inside air film conductance, $\frac{1}{f_i}$ = .60 for interior horizontal surfaces

  $\frac{1}{f_i}$ = .68 for interior vertical surfaces
- $R$ = $\frac{1}{C} = \frac{X}{K}$ = measure of the resistance to the passage of heat from 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

## OVERALL THERMAL TRANSMITTANCE: WALLS

$$U_o = \frac{U_w A_w + U_g A_g + U_d A_d \ldots}{A_o} \quad \text{. . . . . . . . . . . EQUATION (53-2)}$$

WHERE:

$U_o$ = the overall thermal transmittance of the gross wall area

$A_o$ = the gross wall area of exterior walls

$U_w$ = the thermal transmittance of all elements of the opaque wall area

$A_w$ = the area of the opaque wall

$U_g$ = the thermal transmittance of the glazing area

$A_g$ = the glazing area, including sash

$U_d$ = the thermal transmittance of the door

$A_d$ = the door area

NOTE: Whre more than one type of wall, window, and/or door is used, the U and A terms for those items shall be expanded into subelements, as:

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

Calculations shall include the effects of all heat flow paths, such as framing members. Wood framing as a percent of opaque wall area is typically:

- 17 percent for 2-inch studs at 12" o.c.
- 15 percent for 2-inch studs at 16" o.c.
- 12 percent for 2-inch studs at 24" o.c.
- 20 percent for 3-inch studs at 16" o.c.

OVERALL THERMAL TRANSMITTANCE: ROOF/CEILING

$$U_o = \frac{U_f \times A_r}{A_o} \quad \text{. . . . . . . . . . . . . . . . . . . . . . EQUATION (53-3)}$$

WHERE:

$U_o$ = the overall thermal transmittance of the gross opaque roof/ceiling area

$A_o$ = the gross opaque area of the roof/ceiling assembly

$U_r$ = the thermal transmittance of all elements of the opaque roof/ceiling area

NOTE: Where more than one type of roof/ceiling is used, the U x A term for that exposure shall be expanded into its subelements, as:

$(U_{r1} \times A_{r1}) + (U_{r2} \times A_{r2}) + (U_{r3} \times A_{r3})$ . . . etc.

Calculations shall include the effects of all heat flow paths, such as framing members. Wood framing as a percent of opaque roof/ceiling area is typically:

- 13 percent for 2-inch joists at 12" o.c.
- 10 percent for 2-inch joists at 16" o.c.
- 6 percent for 2-inch joists at 24" o.c.

## OVERALL THERMAL TRANSMITTANCE: FLOOR

$$U_o = \frac{(U_f \times A_f)}{A_o} \quad \text{. . . . . . . . . . . . . . . . . . . . . . EQUATION (53-4)}$$

WHERE:

$U_o$ = the overall thermal transmittance of the gross floor over unconditioned space

$A_o$ = the gross floor area over an unconditioned floor assembly

$U_f$ = the thermal transmittance of all elements of the opaque floor area

$A_f$ = the gross floor area of the opaque floor assembly

NOTE: Where more than one type of floor assembly is used, the U x A for that exposure shall be expanded into subelements as:

$(U_{f1} \times A_{f1}) + (U_{f2} \times A_{f2}) + \ldots$ (etc.)

Calculations shall include the effects of heat flow paths, such as framing members. Framing as a percent of floor area is typically:

- 13 percent for 2-inch joists at 12" o.c.
- 10 percent for 2-inch joists at 16" o.c.
- 6 percent for 2-inch joists at 24" o.c.
- 10 percent for 2-inch plank and 4-inch beams at 48" o.c.

OVERALL THERMAL TRANSMITTANCE: BUILDING

$UA_{op}$ equal to or less than $UA_o$ . . . . . . . . . . . . . EQUATION (53-5)

WHERE:

$UA_{op}$ = the overall thermal transmittance of the proposed building's envelope calculated as the average of the component $U_o$ derived from Equations 2, 3, and 4 using the $U_o$ value for each building component proportionally.

$UA_{op}$ = $(U_{op1} \times A_1 + U_{op2} \times A_2 + \ldots U_{opn} \times A_n)$

$UA_o$ = the overall thermal transmittance of the building envelope of the standard design calculated as the average of the component $U_o$ derived from the $U_o$ values stated in Table 5-1.

$UA_o$ = $(U_{o1} \times A_1 + U_2 \times A_2 + \ldots U_{on} \times A_n)$

and

$U_{op1}$ = the thermal transmittance of building envelope component 1 derived using Equations 2, 3, or 4 for the proposed building.

$A_1$ = the area $ft^2$ of the building envelope $U_{op1}$.

$U_{op2}$ = the thermal transmittance of building envelope component 2 derived using Equations 2, 3, or 4 for the proposed building.

$A_2$ = the area $ft^2$ of building envelope component $U_{op2}$.

$U_{opn}$ = the thermal transmittance of building envelope component n derived using equations 2, 3, or 4 for the proposed building.

$A_n$ = the area $ft^2$ of building envelope component n.

$U_{o1}$ = the thermal transmittance of building envelope component 1, as stated in Table 5-1.

$A_1$ = the area of building envelope component 1 for the proposed building.

$U_{o2}$ = the thermal transmittance of building envelope component 2, as stated in Table 5-1.

$A_2$ = the area of building envelope component 2 for the proposed building.

$U_{on}$ = the thermal transmittance of building envelope component n as stated in Table 5-1.

$A_n$ = the area $ft^2$ of building envelope component n for the proposed building.

## HEAT STORAGE CAPACITY

HS = D x SH x V . . . . . . . . . . . . . . . . . . . . . . . . EQUATION (53-6)

WHERE:

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

V = Volume of heat storage components.

D = Density of material inside the insulated shell of the building to a depth yielding a thermal resistance of R-1, except in the case of slab floors where only the slab itself is credited. Mass located in conditioned or unconditioned basements withut solar glazing shall not be counted. (lbs/cf).

SH = Specific heat of the material (Btu/bl/$^{o}$F).
The following quantities provide 10 Btu/$^{o}$F or heat storage capacity.

20 square feet of 1/2" gypsum board interior finish of interior walls and partitions.

40 square feet of 1/2" gypsum board on the interior or exterior walls.

1.5 square feet of 8-inch lightweight concrete masonry wall, insulated externally.

1.5 square feet of 4-inch nominal concrete slab floor with tile terrazzo, or plain finish.

Chapter 53 Conversion Equivalent Code

Building Design by Prescriptive Requirements Method

Sec. 5306. (a) General. The provisions of this chapter are applicable to low-rise dwellings and apartment houses.

(b) Building Envelope Requirements. The building envelope requirements of this chapter may be met by installing one of the prescriptive packages in Table 53-O. All components shall comply with the chosen specification over their entire extent, i.e. all windows, all exterior doors, all exterior walls, all roof/ceilings, and all floors except as specified in this section. Installed components shall meet the following requirements:

1. Roof/ceilings A. Ceilings below vented attics and vaulted ceilings shall be insulated to not less than the nominal R value specified in Table 53-O. Where architectural barriers preclude the installation of the specified R Value, roofs/ceilings must be insulated to the maximum extent possible.

B. Blown or poured loose fill insulation may be used in attic spaces where the slope of the roof is not less than 2-1/2 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 joists to the underside of the roof sheathing at the roof ridge. The surface of the installed blown or poured insulation shall be baffled. Baffles shall be of weather-resistant, rigid material capable of retaining the insulation. (See Uniform Building Code section 3205(c).)

C. Adequate cross ventilation shall be maintained above all ceiling insulation by providing both low and high vents or gable end vents. Ventilation openings shall not be blocked by insulation.

D. Attic access doors separating conditioned and unconditioned spaces shall be weatherstripped and insulation equivalent to the R value of the surrounding roof/ceiling/walls shall be attached to the back of the door.

E. If mechanical equipment is installed in the attic, a catwalk passageway shall be provided to permit access to the equipment without compressing the insulation.

2. Exterior walls (Above grade). Above grade exterior walls shall be insulated to not less than the nominal R value specified for walls in Table 53-D. The R value shall be the total value for insulation in stud cavities and/or insulated sheathing. Use of all insulation materials shall be consistent with the manufacturer's approved applications.

3. Exterior walls (Below grade). A. Below grade exterior walls surrounding conditioned space, such as conditioned basements, shall be insulated to not less than the nominal R value specified for below grade walls in Table 53-O.

B. Insulation shall extend from the top of the wall to the top of the footing or floor slab. If installed on the exterior, the below grade wall insulation shall be protected and if exposed on the interior, it shall comply with section 1712 of the Uniform Building Code.

4. Slab-on-grade floors. Slab-on-grade floors shall be insulated along their perimeter, not adjoining conditioned space, to not less than the nominal R value specified for slab-on-grade floors in Table 53-O. Where architectural barriers preclude the installation of the specified R value, slabs must be insulated to the maximum extent practicable.

B. The insulation shall extend downward from the top of the slab to the design frost line or a minimum distance of 24 inches whichever is greater. If the depth of the footing is less than 24 inches, then the insulation shall extend downward to the bottom of the slab or to the base of the foundation footing. Insulation shall be of an approved type.

EXCEPTION: For monolithic slabs, the insulation shall extend downward from the top of the slab to the bottom of the thickened edge.

5. Floors over unconditioned space. A. Floors over unconditioned spaces shall be insulated to not less than the nominal R value in Table 53-O.

B. A ground cover of 6 mil opaque polyethylene or other approved equal shall be installed in all crawl spaces.

C. Crawl spaces shall be ventilated by openings in exterior foundation walls. Such openings shall have a net area of not less than one square foot for each 150 square feet of underfloor areas. Openings shall be located as close to corners as practical and shall provide cross ventilation. (See Uniform Building Code Section 2516(c)6.)

6. Glazing. A. All glazing shall be at a minimum, double glazing. Insulating glass with at least 1/2 inch air space or approved storm sash shall be considered to comply with this code.

B. Effective solar glazing. A passive solar building is required to have at least ten (10) percent of the building's gross floor area in glazing that meets the following specifications:

1. The glazing area shall be oriented within 45 degrees of true south with a maximum of 60 percent between 31 and 45 degrees of true south.

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

3. The glazing shall have a transmission coefficient greater than or equal to 0.80 for visible light or 0.73 for total solar radiation for a single pane. The insulating glass unit shall have total visible light transmission equal to or greater than 0.67 and total solar energy transmission equal to or greater than 0.55.

4. Documentation in the form of a sun chart, photograph or other evidence, demonstrates that the glazing area oriented within 30 degrees of true south must receive direct solar exposure for at least 3 hours between 10 a.m. and 2 p.m. solar time on January 21st and March 21st.

5. Documentation in the form of a sun chart, photograph or other evidence demonstrates that the glazing area oriented between 31 and 45 degrees east or west of true south must not be shade for at least 2 hours between 9 a.m. and 12 noon standard time if east of south, and 12 noon and 3 p.m. standard time if west of south on January 21st and March 21st.

6. The building or addition shall contain a heat storage capacity equivalent to at least 20 Btu/°F for each square foot of solar glazing when the qualifying area is between eight (8) and fourteen (14) percent of the gross habitable conditioned floor area of the building and at least 45 Btu/°F for each square foot of solar glazing when the qualifying area exceeds fourteen (14) percent of the gross conditioned floor area of the building. This heat storage capacity shall be 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. If the storage medium is not within the space containing the qualifying glazing, an acceptable natural or mechanical means of transferring the heat to the heat storage medium shall be provided. Where a mass- or water-wall is located immediately behind the glazing, the mass- or water-wall shall be considered as having an acceptable natural means of transferring the heat to other heat storage capacity within that space. Heat storage capacity shall be calculated using Equation 53-6 and accepted analysis methods.

7. Opaque wall area covered with glazing, such as mass- or water-walls, which meets all of the requirements of this subsection, shall be considered solar glazing.

(c) Air Leakage. (Reserved)

(d) Building Mechanical Systems. (Reserved)

(e) Service Hot Water Heating. Residential electric hot water heaters shall be insulated with a thermal resistance of 16 (R-16). Additional insulation shall not be required if the water heater has been certified by the manufacturer to have a standby loss no greater than 2.8 watts per square foot of external area. All storage tanks shall be placed on an incompressible, non-combustible, insulated surface with a thermal resistance of at least 10 (R-10).

EXCEPTION: Where walls or other barriers prevent installation of R-16 insulation, electric water associated tanks shall be insulated to the maximum extend possible.

TABLE NO. 53-A
THERMAL PERFORMANCE CRITERIA FOR LOW-RISE RESIDENTIAL DWELLINGS CONVERTING TO ELECTRIC SPACE HEAT

| COMPONENT | GROUP R DIVISION 3 ($U_o$ Value) | GROUP R DIVISION 1 ($U_o$ Value) |
|---|---|---|
| Walls | .20 | .24 |
| Roof/ceiling | .028 | .035 |
| Floors over unconditioned | | |
| Space-Enclosed | .08 | .08 |
| Exposed | .035 | .05 |
| Slab-on-grade floors | | |
| Unheated (R value) | 5.0 | 5.0 |
| Heated (R value) | 8.0 | 8.0 |

TABLES 53-B through 53-K

(Reserved)

TABLE NO. 53-L
MINIMUM PIPE INSULATION

| Piping System Types | Fluid Temp Range (°F) | INSULATON THICKNESS IN INCHES FOR PIPE SIZES[2] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Run-Outs 2"[1] | 1" and Less | 1.25" to 2" | 2.5" to 4" | 5" to 6" | 8" and Larger |
| Heating and Hot Water Steam and Hot Water | | | | | | | |
| High Pressure | 306-450 | 1.5 | 2.5 | 2.5 | 3.0 | 3.5 | 3.5 |
| Med. Pressure | 251-305 | 1.5 | 2.0 | 2.5 | 2.5 | 3.0 | 3.0 |
| Low Pressure | 201-250 | 1.0 | 1.5 | 1.5 | 2.0 | 2.0 | 2.0 |
| Low temp. | 120-200 | 0.5 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| Steam Condensate (for feed water) | Any | 1.0 | 1.0 | 1.5 | 2.0 | 2.0 | 2.0 |
| Cooling systems | | | | | | | |
| Chilled Water | 40-55 | 0.5 | 0.5 | 0.75 | 1.0 | 1.0 | 1.0 |
| Refrigerant or Brine | Below 40 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 |

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

2 For piping exposed to outdoor air, increase thickness by 0.5 inch.

TABLE NO. 53-N
LIGHTING POWER BUDGET[1]

| Occupancy Group | Occupancy Description | Lighting Power Budget[2] (Watts/sq ft) |
|---|---|---|
| A-1 | Assembly w/stage: occupancy of 100 or more | 1.1 |
| A-2 | Assembly w/stage: occupancy of less than 1000 | 1.1 |
| A-2.1 | Assembly w/o stage: occupancy of 300 or more other than B-2 and E | 1.1 |
| | Drinking and dining establishment | 1.85 |
| A-3 | Assembly w/o stage: occupancy of less than 300 other than B-2 and E | 1.1 |
| | Drinking and dining establishment | 1.85 |
| A-4 | Stadiums, reviewing stands and amusement park structures not included in A or B-1, B-2 and B-3 | 1.1 |
| B-1 | Gasoline and service stations: includes the office, waiting room and pump islands plus 5 feet on each side of the island | 2.0 |
| | Storage garages | 0.3 |
| B-2 | Office buildings, wholesale stores, municipal police and fire stations | 2.0 |
| | Retail stores and museums | |
| | - less than 100 square feet | 5.0 |
| | - 1000 to 6000 square feet | 4.0 |
| | - 6000 to 20,000 square feet | 3.0 |
| | - over 20,000 square feet | 2.0 |
| | Drinking and dining establishments: load of less than 50 | 1.85 |
| | Workshops using material not highly flammable or combustible | 2.0 |
| | Storage and warehouses | 0.7 |
| B-3 | Aircraft hangars | 0.7 |
| | Open parking garages | 0.3 |
| B-4 | Ice plants, power plants, pumping plants, cold storage and creameries | 1.0 |
| | Factories and work shops | 2.0 |
| | Storage | 0.7 |
| | Sales rooms | 2.0 |
| | Shipyard structures | 0.7 |
| E-1 | Schools and daycare centers | 2.0 |
| H-1 | Storage | 0.7 |
| | Handling | 2.0 |

continued

TABLE NO. 53-N
LIGHTING POWER BUDGET[1]
(continued)

| Occupancy Group | Occupancy Description | Lighting Power Budget[2] (Watts/sq ft) |
|---|---|---|
| H-2 | Storage | 0.7 |
| | Handling, dry cleaning plants, paint stores | 2.0 |
| | Paint shops and spray painting rooms | 2.5 |
| H-3 | Warehouses | 0.7 |
| | Other | 2.0 |
| H-4 | Auto repair and body shops | 2.0 |
| | Paint spray booths | 5.0 |
| H-5 | Aircraft repair hangars | 2.0 |
| I-1 | Institutions | 2.0 |
| I-2 | Administrative support services | 2.0 |
| I-3 | Nursing areas | 2.0 |
| R-1<br>R-3 | Residential buildings | Exempt |

1 In case of an occupancy not specifically mentioned above, the lighting power budget in watts per square foot shall be determined by the Building Official based upon the budget for the most comparable occupancy specified.

2 Watts/ft$^2$ of room may be increased by two (2) percent per foot of height above 20 feet.

TABLE 6-1

PRESCRIPTIVE REQUIREMENTS FOR ALL GROUP R OCCUPANCY RESIDENTIAL

BUILDINGS CONVERTING TO ELECTRIC SPACE HEAT

| | PACKAGE | | |
|---|---|---|---|
| | A | B | C |
| Component | Well Insulated | Passive Solar | Heat Pump[1] |
| BUILDING ENVELOPE | | | |
| Minimum Nominal R Value | | | |
| Roof/ceiling | R-38 | R-30 | R-30 |
| Above grade walls | R-11 | R-11 | R-11 |
| Below grade walls | R-11 | R-11 | R-11 |
| Slab-on-grade floors | R-5 | R-5 | R-5 |
| Floor over unconditioned space | R-30 | R-19 | R-19 |
| GLAZING | | | |
| Type | Double | Double | Double |

1 Heat Pump shall have a heating season performance factor (HSPF) of at least 6.8



☆GPO1987-794-064