2h. 1783

SAN/1230-1

MODEL CODE FOR ENERGY CONSERVATION IN NEW BUILDING CONSTRUCTION

DECEMBER 1977

MASTER

**Prepared For The
U.S. DEPARTMENT OF ENERGY
Washington, D.C.**

UNDER CONTRACT No. E[04-3] 1230

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

This report has been reproduced directly from the best available copy.

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

Price: Paper Copy \$6.00
Microfiche \$3.00

MODEL CODE FOR ENERGY CONSERVATION IN NEW BUILDING CONSTRUCTION

DECEMBER 1977

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DEVELOPED BY
BUILDING OFFICIALS & CODE ADMINISTRATORS' INTERNATIONAL, INC.
INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS
SOUTHERN BUILDING CODE CONGRESS INTERNATIONAL, INC.
FOR
NATIONAL CONFERENCE OF STATES ON BUILDING CODES AND STANDARDS, INC.

For The
U.S. DEPARTMENT OF ENERGY
Division of Buildings and
Community Systems
Washington, D.C. 20545

UNDER CONTRACT No. E(04-3) 1230

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

ABSTRACT

In response to the recognized lack of existing consensus standards directed to the conservation of energy in building design and operation, the preparation and publication of such a standard was accomplished with the issuance of ASHRAE Standard 90-75 "Energy Conservation in New Building Design", by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., in 1975. This standard addressed itself to recommended practices for energy conservation, using both depletable and non-depletable sources.

With a nationally recognized standard now available, consistent and uniform application was determined as necessary. The development of a national model building design regulatory document was accomplished through funding by the United States Department of Energy by those organizations primarily concerned with code development and writing.

A model code for energy conservation in building construction has been developed, setting forth the minimum regulations found necessary to mandate such conservation. The code addresses itself to the administration, design criteria, systems elements, controls, service water heating and electrical distribution and use, both for depletable and non-depletable energy sources.

The technical provisions of the document are based on ASHRAE 90-75 and it is intended for use by state and local building officials in the implementation of a statewide energy conservation program.

Key words: Administrative procedures; ASHRAE 90-75; building regulations; buildings; codes; energy conservation; design - energy conservation; energy sources, depletable and non-depletable; new buildings; model codes; regulations - energy conservation; standards - energy conservation.

FOREWORD

The Model Code for Energy Conservation in New Building Construction is the result of a contract between the National Conference of States on Building Codes and Standards, Inc. (NCSBCS) and the United States Department of Energy (DOE). The DOE funding support provided that NCSBCS contract with the three model code groups, Building Officials & Code Administrators International, Inc., International Conference of Building Officials, and Southern Building Code Congress International, Inc., to work together in a joint effort to produce this document. The Code incorporates ongoing energy conservation code development efforts by the model code agencies and the various State energy conservation activities.

The following items should be noted by all users of this Code:

I. Differences from ASHRAE Standard 90-75

The following differences will be found when comparing this Code to Standard 90-75.

- a. Metric Equivalents Deleted: The S. I. equivalent formulas and units have been deleted from the Code. This is in accordance with the present code format. It is anticipated that the S. I. units will be added when the nation's building codes are revised to include such units.
- b. COP Improvement Targets: The improved COP target levels for HVAC equipment have been deleted since it is not possible to adopt a building code containing future enforcement provisions. Future anticipated amendments will include the 1980 COP levels at the time they are effective.
- c. Code Restructured: The Code has been restructured into a three-path approach. Compliance with any one of these paths is considered to meet the intent of this Code.

Path 1 (Section 4 of this Code) is the systems analysis design approach. This section includes non-depletable energy source utilization (Standard 90-75, Chapters 10 and 11).

Path 2 (Section 5 of this Code) is the component performance design approach (Standard 90-75, Chapters 4 through 9).

Path 3 (Section 6 of this Code) contains acceptable practice provisions for conventional residential buildings of three stories or less and small (heated only) commercial buildings of frame, concrete, or masonry-wall construction, all of less than 5,000 square feet in floor area. This section permits these structures to be constructed in accordance with designated provisions in lieu of performing a thermal analysis. Users of this section should be aware that it is generally more conservative and that greater initial construction economy may be obtained by utilizing Section 4 or 5.

- d. Charts and Graphs: The various graphs relative to envelope design have been relocated to the Reference Standards and replaced by a matrix providing spaces for the appropriate values. The reason for this is that the Code, when adopted by a local regulatory agency, becomes site-specific, and after adoption of the Code and identification of the appropriate U_o , OTTV, etc., values, there is no further need for the graphs.

One additional change involves creating a section entitled "Design Conditions", containing the basic design criteria. This follows the traditional building code approach of a chapter of design loads followed by chapters regulating specific material design.

- e. Reference Documents: Reference documents have been replaced by Standards which are adopted with the Code.
- f. Registered Engineer: An administrative section permitting the Building Official to require the design be prepared by a registered engineer or architect is incorporated in the Code. Additional language requiring registered professionals for designs involving systems approach has been included but noted as optional by the adopting agency. This permits implementation when not in conflict with the various State professional practice acts.
- g. Mobile Homes and Manufactured Buildings: Mobile homes are regulated under HUD preemptive Federal Standards and thus any requirements for mobile homes are not included in this Code. A manufactured building is regulated by building codes and thus should comply with the requirements contained herein.

II. Comment Phase

Several thousand copies of a preliminary draft of the Code were distributed for public review and comment. In addition, a public

forum was held to provide opportunity for any additional comment. All comments were reviewed and considered by the project team. Items included were:

- a. Performance Standards: Concern was expressed that the Code is not sufficiently performance-based. The project team feels that the Code provides sufficient flexibility for utilization of future performance concepts with the addition of a new section, chapter, or appendix as appropriate. It is anticipated that such provisions would be incorporated when the research is completed and the proposed standards have undergone a consensus review.
- b. Section 6 - Design by Accepted Practice: Many comments received from industry groups related to the construction sections provided in Section 6, compared to the many construction practices throughout the country and to the Manuals of Accepted Practice (for Energy Conservation) currently under development. The details shown in the appendix represent typical construction practices. Assemblies complying with this Code include, but are not limited to, those shown. The project team recommends that the various details contained in the appendix be expanded, supplemented by and used in conjunction with those industry manuals, and the currently available approval mechanisms through the Model Code research reports and similar statewide programs.

In addition, Section 6 should be in no way confused with the planned ASHRAE Manual of Acceptable Practices, intended to provide guidance for utilization of the Standard 90-75, and potentially this Code.

- c. ASHRAE Standard 90-75: Many comments received suggested technical changes to Standard 90-75. These comments were forwarded to ASHRAE for their consideration of possible changes to the Standard. Changes to ASHRAE Standard 90-75, subsequently adopted by ASHRAE, were not within the scope of this project. These items will be considered in future revision cycles of this Code.
- d. Environmental Zones not Presently Covered by Standard 90-75: Areas such as far northern climates with degree days exceeding 12,000 and sub-tropical climates are subjects of current research and additional requirements will be considered in future revisions.

III. Approval

The project team is aware that many industries not previously regulated by building standards and codes will not have their products and work subject to inspection and product approval. There are existing approval systems prepared to react to and accept those newly-regulated products. Available for industry is the National Research Board of the Council of American Building Officials (CABO), the individual model code groups research report systems and the several statewide approval systems, as well as the traditional approval agencies such as UL and AGA. Thus, manufacturers have available to them an approval system to meet their distribution and sales needs on a statewide, regional or national basis.

IV. Adoption and Implementation

The project team feels sufficient administrative provisions have been included to integrate this Code with presently adopted codes and that the Code could be easily incorporated into traditional building, mechanical, electrical and plumbing codes. In addition, with minor amendments, the Code can serve on its own.

Certain items in the Code have been bracketed and their use will depend upon the individual agency, state law and local needs.

Users of the Code should consider that buildings constructed in accordance with its requirements will be better sealed than buildings of the past and consideration must be given to combustion air for gas furnaces, water heaters and appliances, fireplaces, etc. In addition, there is concern over the effect of insulation in walls and fire performance. Research is necessary to provide answers to these questions in the future. The use of this Code should in no way nullify the enforcement of any other health and safety requirement.

Local agencies must also complete the environmental data required in Section 3 and 5 based on local environmental history.

Adopting agencies should be aware of various training courses developed under another phase of this joint effort. The course materials for the training of those personnel in the use of the Code will be made available to state governments.

V. Acknowledgment

Credit is given to the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., for the use of technical provisions, figures and tables contained in ASHRAE Standard 90-75, "Energy Conservation in New Building Design."

The Code is based on the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) Standard 90-75. Each paragraph of ASHRAE Standard 90-75 was reviewed for appropriateness as an enforceable provision with applicable sections modified into code language. These sections are considered no less stringent than ASHRAE Standard 90-75. The Code has been restructured in relation to ASHRAE Standard 90-75, and requirements have been added to regulate new additions to existing buildings and adds acceptable practice provisions.

Specifically, the following figures and tables from ASHRAE Standard 90-75 are included in this Code:

Figure 1, U_o Walls-Group R Buildings (page 64)
Figure 2, R Values-Slab on Grade (page 65)
Figure 3, U_o Walls-Heating (page 66)
Figure 4, U_o -Roofs and Ceilings (page 67)
Figure 5, U_o Values-Floors over Unheated Spaces (page 68)
Figure 6, Overall Thermal Transfer Value Walls Cooling (page 69)
Figure 7, Solar Factor (SF) Values (page 70)

Table 5-4, Minimum COP for Heat Pumps, Heating Mode (page 40)
Table 5-5, Minimum EER and COP for Electrically Driven Heating, Ventilating and Air Conditioning System Equipment-Cooling (page 40)
Table 5-6, Minimum EER and COP for Electrically Driven Heating, Ventilating and Air Conditioning System Components (page 40)
Table 5-7, Minimum COP for Heating, Ventilating and Air Conditioning System Heat Operated Cooling Equipment (page 41)
Table 5-8, Minimum Pipe Insulation (page 41)
Table 5-9A, HVAC System Heating Equipment (Heat Pumps) Standard Rating Conditions (page 42)
Table 5-9B, HVAC System Equipment Standard Rating Conditions-Cooling (page 42)
Table 5-9C, Applied HVAC System Components Standard Rating Conditions-Cooling (page 42)

Table 5-10A, Lamp Efficacies (page 51)
Table 5-10B, Luminaire Coefficients of Utilization (CU) (page 51)
Table 5-10C, Reflectances & Light Loss Factors (page 51)

Table 6-4, Minimum COP for Heat Pumps, Heating Mode (page 57)
Table 6-5, Minimum EER and COP for Electrically Driven Heating,
Ventilating and Air Conditioning System Equipment-Cooling
(page 57)
Table 6-6, Minimum EER and COP for Electrically Driven Heating,
Ventilating and Air Conditioning System Components (page 57)
Table 6-7, Minimum COP for Heating, Ventilating and Air Condition-
ing System Heat Operated Cooling Equipment (page 58)
Table 6-8, Minimum Pipe Insulation (page 58)

The Project Team consisted of the following persons:

Project Team Management was under the direction of:

Henry S. Wakabayashi, P.E., Energy Program Director,
National Conference of States on Building Codes and Standards,
Inc.

Code Development was by:

Kenneth Schoonover, P.E., Staff Engineer,
Building Officials & Code Administrators International, Inc.

T. H. Carter, P.E., Executive Director,
International Conference of Building Officials

Billy Manning, P.E., Education Director,
Southern Building Code Congress International, Inc.

Melvyn Green, P.E., Consulting Engineer,
Model Code Group Coordinator

TABLE OF CONTENTS

	<u>PAGE</u>
Abstract	iii
Foreword	iv

<u>SECTION</u>	<u>TITLE</u>	
1	ADMINISTRATION AND ENFORCEMENT	3
	101.0 Scope and General Requirements	3
	102.0 Materials and Equipment.	4
	103.0 Alternate Materials - Method of Construction, Design, or Insulating Systems.	5
	104.0 Plans and Specifications	5
	105.0 Inspections.	6
	106.0 Validity	6
2	DEFINITIONS.	7
	201.0 General Definitions.	7
3	DESIGN CONDITIONS.	15
	301.0 Design Criteria.	15
	302.0 Thermal Design Parameters.	15
	303.0 Mechanical Ventilation Criteria.	16
4	BUILDING DESIGN BY SYSTEMS ANALYSIS AND DESIGN OF BUILDINGS UTILIZING NON-DEPLETABLE ENERGY SOURCES. . .	17
	401.0 Scope.	17
	402.0 Systems Analysis	17
	403.0 Non-Depletable Source Analysis	19

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
5	BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH . . .	22
	501.0 Scope	22
	502.0 Building Envelope Requirements.	22
	503.0 Building Mechanical Systems	29
	504.0 Service Water Heating	39
	505.0 Electrical Power & Lighting	45
6	BUILDING DESIGN BY ACCEPTABLE PRACTICE.	52
	601.0 Scope	52
	602.0 Building Envelope Requirements.	52
	603.0 Building Mechanical Systems	53
	604.0 Service Water Heating	55
	605.0 Electrical Power and Lighting	56
7	STANDARDS	61
	FIGURES 1-7	64
	APPENDIX.	71
	Wall Assemblies	72
	Roof/Ceiling Assemblies	75
	Floor Assemblies.	76

SECTION 1 - ADMINISTRATION AND ENFORCEMENT

SECTION 101.0 SCOPE AND GENERAL REQUIREMENTS

101.1 TITLE

This Code shall be known as the "Model Code for Energy Conservation in New Building Construction", and may be cited as such; and will be 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, and illumination systems and equipment which will enable the effective use of 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 energy. These provisions are structured to permit compliance with the intent of this Code by any one of the three paths of design:

- (a) a systems approach for the entire building and its energy-using sub-systems which may utilize non-depletable sources, Section 4;
- (b) a component performance approach for various building elements and mechanical systems and components, Section 5; or
- (c) specified acceptable practice, Section 6.

Compliance with any one of these paths meets the intent of this Code. This Code is not intended to abridge any safety or health requirements required under any other applicable codes or ordinances.

101.3 SCOPE

This Code sets forth minimum requirements for the design of new buildings and structures or portions thereof and additions 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 energy.

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

(a) EXEMPT BUILDINGS.

1. Buildings and structures or portions thereof whose peak design rate of energy usage is less than three and four tenths (3.4) Btu/h per square foot or one point zero (1.0) watt per square foot of floor area for all purposes.
2. Buildings and structures or portions thereof which are neither heated nor cooled by fuel.

(b) APPLICATION TO EXISTING BUILDINGS.

1. Additions to Existing Buildings. Additions to existing buildings or structures may be made to such buildings or structures without making the entire building or structure comply. The new addition shall conform to the provisions of this Code as they relate to new construction only.
2. Historic Buildings. Historic buildings are exempt from this Code. This exemption shall apply to those buildings which have been specifically designated as historically significant by the State or local governing body, or listed in "The National Register of Historic Places" or which have been determined to be eligible for listing.
3. Change of Occupancy. Any change in the occupancy or use of any 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.

102.0 MATERIALS AND EQUIPMENT

102.1 IDENTIFICATION

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

102.2 MAINTENANCE INFORMATION

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

103.0 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.

104.0 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 be prepared by an engineer or architect licensed to practice by the State. [All designs submitted under the provisions of Section 4 shall be prepared by an engineer or architect licensed to practice by the State.]¹

104.2 DETAILS

The plans and specifications shall show in sufficient detail all pertinent data and features of the building and the equipment and systems as herein governed including, but not limited to: design criteria, exterior envelope component materials, U values of the envelope systems, R values of insulating materials, size and type of apparatus and equipment and systems controls and other pertinent data to indicate conformance with the requirements of the Code.

¹Shall be adopted when not in conflict with State practice acts.
See Item IV of Foreword.

105.0 INSPECTIONS

105.1 GENERAL

All 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 on all buildings when completed and ready for occupancy.

105.4 REINSPECTION

The Building Official may cause any structure to be reinspected.

106.0 VALIDITY

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

SECTION 2 - DEFINITIONS

201.0 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 Section.

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

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

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

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.)

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

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

BUILDING OFFICIAL. The 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.

COEFFICIENT OF BEAM UTILIZATION (CBU). The ratio of the luminous flux (lumens) reaching a specified area directly from a floodlight or projector to the total beam luminous flux.

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

Electrically Operated HVAC Equipment - Cooling 503.4(e)2

Applied HVAC System Components - Cooling 503.4(f)1

Heat Operated HVAC System Equipment - Cooling 503.4(g)1

Heat Pump - Heating 503.4(b)2

COEFFICIENT OF UTILIZATION (CU). The ratio of the luminous flux (lumens) from a luminaire received on the work plane to the lumens emitted by the luminaire's lamps alone.

COLOR RENDITION. General expression for the effect of a light source on the color. Appearance of objects in conscious or sub-conscious comparison with their color appearance under a reference light source.

COMFORT ENVELOPE. The area on a psychrometric chart enclosing all those conditions described in Std RS-4, Figure 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.

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 65F there exist as many Degree Days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65F.

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

ENERGY. The capacity for doing work; taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical, 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 cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions.

ENERGY, RECOVERED. (See RECOVERED ENERGY.)

EQUIVALENT SPHERE ILLUMINATION (ESI). The level of sphere illumination which would produce task visibility equivalent to that produced by a specific lighting environment.

EXTERIOR ENVELOPE. (See BUILDING ENVELOPE.)

FLOODLIGHTING. A lighting system designated to light an area using projector-type luminaires usually capable of being pointed in any direction.

FUEL. A substance which may be burned to give heat or generate electricity; a nuclear substance used to generate electricity.

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 centerline of walls separating buildings.

Covered walkways, open roofed-over areas, porches and similar spaces shall be excluded.

The gross floor area does not include such features as pipe trenches, exterior terraces or steps, chimneys, room overhangs, etc.

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

The gross area of exterior 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 outdoor air and enclose a heated or mechanically cooled space including interstitial areas between two such spaces.

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

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

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

HVAC. Heating, ventilating and air conditioning.

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

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.

LIGHT LOSS FACTOR (LLF). A factor used in calculating the level of illumination after a given period of time and under given conditions. It takes into account temperature and voltage variations, dirt accumulation on luminaire and room surfaces, lamp depreciation, maintenance procedures, and atmospheric conditions.

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 power supply.

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

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

NON-DEPLETABLE ENERGY SOURCES. Sources of energy (excluding minerals) derived from incoming solar radiation including photosynthetic processes; from phenomena resulting therefrom including wind, waves, and tides, lake or pond thermal differences; and energy derived from the internal heat of the earth, including nocturnal thermal exchanges.

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

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

OUTSIDE 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 Std RS-10.)

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

POWER. In connection with machines, power is the time rate of doing work. In connection with the transmission of energy of all types, power refers to the rate at which energy is transmitted; in customary units, it is measured in watts (W) or British thermal units per hour (Btu/h).

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.)

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

REFLECTANCE. The ratio of the light reflected by a surface to the light falling upon it.

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

The gross area of a roof assembly consists of the total interior surface of such assembly, including skylights exposed to the heated or mechanically cooled space.

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

ROOM CAVITY RATIO (RCR). A number related to room dimensions used in average illumination calculations.

SEQUENCE. A consecutive series of operations.

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

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

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

SHADING COEFFICIENT (SC).

$$SC = \frac{\text{Solar Heat Gain of Fenestration (West Elev. at 4P.M., 9/21)}}{\text{Solar Heat Gain Unshaded DSB (West Elev. at 4P.M., 9/21)}}$$

where

DS means double strength

B means grade class

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

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

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

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

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. It is designed to provide the functions of air-circulating, air cleaning, cooling and heating with controlled temperature, and dehumidifying, and may optionally include the function of humidifying. When such

equipment is provided in more than one assembly the separate assemblies shall be designed to be used together.

VEILING REFLECTIONS. Regular reflections superimposed upon diffuse reflections from an object that partially or totally obscure the details to be seen by reducing the contrast. This sometimes is called reflected glare.

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 Std RS-3 and Section 3 of this Code.)

WORK PLANE. The plane at which work usually is done and at which the illumination is specified and measured. Unless otherwise indicated, this is assumed to be a horizontal plane 30 inches above the floor.

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.

SECTION 3 - DESIGN CONDITIONS

301.0 DESIGN CRITERIA

301.1 GENERAL

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

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 provided in this Code when requirements of the exterior envelope differ.

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

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.

302.0 THERMAL DESIGN PARAMETERS

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

302.1 EXTERIOR DESIGN CONDITIONS

EXTERIOR DESIGN CONDITIONS		
WINTER ¹	Design Dry-Bulb	F
	Design Dry-Bulb	F
SUMMER ¹	Design Wet-Bulb	F
DEGREE DAYS HEATING		
DEGREES NORTH LATITUDE		

¹The outdoor design temperature shall be selected from the columns of 97 1/2° values for winter and 2 1/2° values for summer from tables in Std RS-1. 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

- (a) Indoor Design Temperature. Indoor design temperature shall be 72F for heating and 78F for cooling.

EXCEPTION: 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 Std RS-4 shall be selected for minimum total HVAC system energy use.

303.0 MECHANICAL VENTILATION CRITERIA

303.1 VENTILATION

Ventilation air shall conform to Std RS-3. The minimum column value of Std RS-3 for each type of occupancy shall be used for design. The ventilation quantities specified in Section 6 of Std RS-3 are for 100 percent outdoor air ventilating systems. Reduction of up to 33 percent of the specified minimum outdoor air requirement in Section 5 of Std RS-3 for recirculating HVAC systems is permitted.

EXCEPTIONS: If outdoor air quantities other than those specified in Std RS-3 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.

SECTION 4 - BUILDING DESIGN BY SYSTEMS ANALYSIS AND
DESIGN OF BUILDINGS UTILIZING NON-DEPLETABLE ENERGY SOURCES

401.0 SCOPE

401.1 GENERAL

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

402.0 SYSTEMS ANALYSIS

402.1 ENERGY ANALYSIS

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

EXCEPTION: Sections 5 and 6 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 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 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 Section 5 or Section 6 and the proposed alternative design shall be designed on a common basis as specified herein:

- (a) The comparison shall be expressed as Btu input per square foot of gross floor area per year.

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

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 all 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 Section 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 Section 4 of this Code.

EXCEPTION: Proposed alternative designs for one- and two-family dwellings, multi-family buildings, and for commercial and industrial structures having an area of 5,000 square feet or less having the indoor temperature controlled from a single point are exempted from the full-year energy analysis described in paragraph 402.3(b). However, comparison of energy consumption between the alternative design and the standard design shall be provided.

403.0 NON-DEPLETABLE SOURCE ANALYSIS

403.1 GENERAL

Any proposed building utilizing solar, geothermal, wind or other non-depletable energy sources for all or part of its energy source shall meet the requirements of Section 401 of this Code, except such non-depletable energy may be excluded from the total annual energy consumption allowed for the building by that section.

- (a) To qualify for this exclusion, such energy must be derived from a specific collection, storage and distribution system. The solar energy passing through windows shall also be considered as qualifying if such windows are provided with:
 - 1. operable insulating shutters or other devices which, when drawn or closed, shall cause the window area to reduce maximum outward heat flows to those in accordance with Section 502.3(a) and Section 502.4 and,

2. the window areas are shaded or otherwise protected from direct rays of the sun during periods when cooling is required.
- (b) Exclusion shall also be granted where nocturnal cooling processes are used in lieu of energy consuming mechanical cooling equipment.
- (c) All other criteria covered in Sections 401 and 402 shall apply to the proposed alternative designs utilizing non-depletable sources of energy.

403.2 DOCUMENTATION

Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis, as specified in Section 402. The report shall provide technical detail on the alternative building and system designs and on the data employed in and resulting from the comparative analyses as to verify that both the analyses and the designs meet the criteria of Sections 401, 402, and 403 of this Code.

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

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

EXCEPTIONS: Proposed alternative designs for residential and commercial structures of less than 20,000 square feet that derive a minimum of 30 percent of their total annual energy usage from non-depletable sources or from nocturnal cooling shall be exempt from the requirement of a full year energy system analysis, providing that the annual input of such non-depletable sources or the extent of such nocturnal cooling can be expected to meet the demands imposed by the proposed alternative design.

Other commercial, institutional and industrial structures that derive over 50 percent of their annual thermal requirements (heating, cooling, service water heating) or over 30 percent of their annual total energy requirements from non-depletable

sources shall be exempted from comparing the proposed design to a standard design which follows the provisions of Section 402.1. Documentation verifying the percentage of annual energy use derived from such non-depletable sources shall be required as provided in Section 403.2.

SECTION 5 - BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH

501.0 SCOPE

501.1 GENERAL

All buildings that are heated or mechanically cooled shall be constructed so as to provide the required thermal performance of the various components.

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

502.0 BUILDING ENVELOPE REQUIREMENTS

502.1 GENERAL

- (a) The stated U_o value of any assembly such as roof/ceiling, wall or floor may be increased and the U_o 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 U_o values specified in Tables 5-1 and 5-2.
- (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:
 - 1. for thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly; and,
 - 2. for gross area purposes, be based upon the interior face of the upper plenum surface.

502.2 CRITERIA FOR GROUP "R" - RESIDENTIAL BUILDINGS

For the purposes of this Code, Group R-Residential Buildings shall include:

Type A-1 - Detached one- and two-family dwellings;

Type A-2 - All other residential buildings, three stories or less in height.

(a) HEATING AND COOLING CRITERIA.

1. Any Residential building as herein defined that is heated or mechanically cooled shall have a combined thermal transmittance value (U_o) of the gross area of the elements of the exterior building envelope not exceeding the value given in Table 5-1. Equation 1 shall be used to determine acceptable combinations of building components and thermal properties to meet this requirement.
2. Floors Over Unheated Spaces: For floors of heated or mechanically cooled spaces over unheated spaces, the U_o value shall not exceed the value given in Table 5-1.
3. Slab on Grade Floors: For slab on grade floors the thermal resistance of the insulation around the perimeter of the floor shall not be less than the value given in Table 5-1. 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 an approved type.

TABLE 5-1¹

ELEMENT	MODE	TYPE A-1 BUILDINGS	TYPE A-2 BUILDINGS
		U_o	U_o
WALLS ²	HEATING OR COOLING		
ROOF/CEILING ³	HEATING OR COOLING		
FLOORS OVER UNHEATED SPACES	HEATING OR COOLING		
HEATED SLAB ON GRADE	HEATING	R VALUE	R VALUE
UNHEATED SLAB ON GRADE	HEATING	R VALUE	R VALUE

¹Values shall be determined by using the graphs (Figures 1, 2 and 5) contained in Section 7 (based on Std RS-9); using heating degree days as specified in Section 302.0.

²Walls: The requirements for locations with less than 500 heating degree days shall be:

- (a) No maximum U_o if building is heated only.

- (b) If the building is to be mechanically cooled when built, or if provision is made for the future addition of mechanical cooling, the maximum U_o for walls shall be 0.30 Btu/h ft²F.

³The combined thermal transmittance (U_o) for roof/ceilings shall not exceed 0.05 Btu/h ft²F for geographic areas with 8000 or less Fahrenheit Heating Degree Days and shall not exceed 0.04 Btu/h ft²F for geographic areas with more than 8000 Fahrenheit Heating Degree Days.

EXCEPTION: Roof/ceiling assemblies in which the finished interior surface is the underside of the roof deck, may have a maximum U_o value of 0.08 Btu/h ft²F.

502.3 CRITERIA FOR ALL OTHER BUILDINGS

(a) HEATING CRITERIA .

1. Buildings, other than Group R Buildings regulated by paragraph 502.2, that are heated shall have a combined thermal transmittance value (U_o) of the gross area of the elements of the exterior building envelope not exceeding the values given in Table 5-2. Equation 1 shall be used to determine acceptable combinations of building components and thermal properties to meet this requirement.
2. Floors Over Unheated Spaces: For floors of heated spaces over unheated spaces, the U_o value shall not exceed the value given in Table 5-2.
3. Slab on Grade Floors: For slab on grade floors the thermal resistance of the insulation around the perimeter of the floor shall not be less than the value given in Table 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 an approved type.

(b) COOLING CRITERIA .

1. Walls: Any building that is mechanically cooled shall have an overall thermal transfer value, OTTV, for the gross area of exterior walls, not exceeding the values given in Table 5-2. Equation 2 shall be used to determine acceptable combinations of building components and thermal properties to meet these requirements.

2. **Roof/Ceiling:** Any building that is mechanically cooled shall have a combined thermal transmittance value (U_o) for the roof/ceiling not exceeding that specified in Table 5-2.

Table 5-2¹

ELEMENT		MODE	VALUE
WALLS	3 STORIES OR LESS	HEATING	U _o
		COOLING	OTTV
		SF*	
	OVER 3 STORIES	HEATING	U _o
		COOLING	OTTV
		SF*	
ROOF/CEILING		HEATING OR COOLING	U _o
FLOORS OVER UNHEATED SPACES		HEATING OR COOLING	U _o
HEATED SLAB ON GRADE		HEATING OR COOLING	R VALUE
UNHEATED SLAB ON GRADE		HEATING OR COOLING	R VALUE

*SF = SOLAR FACTOR

¹Values shall be determined by using the graphs (Figures 2,3,4,5 and 6) contained in Section 7 (based on Std RS-9); using heating degree days as specified in Section 302.0.

EQUATION 1

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

WHERE:

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

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

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

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

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

A_g = glazing area.

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

A_d = door area.

Note: Where more than one type of wall, window, door, roof/ceiling and skylight is used, the U and A terms for those items shall be expanded into subelements as:

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

EQUATION 2

$$OITV = \frac{(U_w A_w T_{DEQ}) + (A_f SF SC) + (U_f A_f \Delta t) \dots}{A}$$

WHERE:

OITV = average or combined thermal transfer value.

A = gross exterior wall.

U_w = U value of opaque wall (All elements.)

A_w = opaque wall area.

U_f = U value of the fenestration area.

A_f = fenestration area.

T_{DEQ} = temperature difference value. (From table below.)

SC = shading coefficient of the fenestration. (See definitions.)

Δt = temperature difference between exterior and interior design condition, F.

SF = solar factor value¹.

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

$$(U_{w1} A_{w1} T_{DEQ1}) + (U_{w2} A_{w2} T_{DEQ2}) + \text{etc.}$$

¹SF = Solar factor shall be determined from Section 7 (based on Std RS-9).

TEMPERATURE DIFFERENCES (T_{DEQ}) FOR USE WITH EQUATION 2

WALLS

WEIGHT OF CONSTRUCTION Lbs/Ft ²	T_{DEQ} FACTOR
0-25	44
26-40	37
41-70	30
71 and Above	23

502.4 AIR LEAKAGE FOR ALL BUILDINGS

- (a) The requirements of this section shall apply to all buildings and structures, or portions thereof, and apply to those locations separating outdoor ambient conditions from interior spaces that are heated or mechanically cooled and are not applicable to the separation of interior conditioned spaces from each other.
- (b) All 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 5-3. Site constructed doors and windows shall be sealed in accordance with Section 502.4(c).
- (c) Exterior joints around windows and door frames; openings between walls and foundations, between walls and roof/ceilings and between wall panels; openings at penetrations of utility services through walls, floors and roofs; and all other such openings in the building envelope shall be caulked, gasketed, weatherstripped or otherwise sealed in an approved manner.

TABLE 5-3 ALLOWABLE AIR INFILTRATION RATES^{1,2}

WINDOWS	RESIDENTIAL DOORS		NON-RESIDENTIAL DOORS
(cfm per foot of operable sash crack)	(cfm per square foot of door area)		(cfm per lin. foot of crack)
	Sliding Glass (Patio Type)	Swinging	Swinging, Sliding, Revolving
0.5	0.5	1.25	11.0

¹When tested at a pressure differential of 1.567 lb/ft.² which is equivalent to the impact pressure of a 25 mph wind.

²Compliance with the criteria for air leakage shall be determined by Std RS-2, Standard Method of Test for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors.

503.0 BUILDING MECHANICAL SYSTEMS

503.1 GENERAL.

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

EXCEPTIONS: Special applications, 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 503.0 when approved by the Building Official.

503.2 CALCULATIONS OF HEATING AND COOLING LOADS

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

- (a) Calculation Procedures. Heating and cooling design loads for the purpose of sizing HVAC systems shall be determined in accordance with one of the procedures described in Chapters 21 or 22 of Std RS-1 or an equivalent computation procedure.
- (b) Infiltration. Infiltration for heating and cooling design loads shall be calculated for all buildings except one- and two-family dwellings by the procedures in Chapters 19, 21 and 22 of Std RS-1. Calculations for one- and two-family dwellings may use the methods identified above or other accepted engineering practice.

503.3 SIMULTANEOUS HEATING AND COOLING

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

- (a) Recovered Energy. Recovered energy, provided the new energy expended in the recovery process is less than the amount recovered, may be used for control of temperature and humidity.
- (b) New Energy for Humidity Control. New energy may be used to prevent relative humidity from rising above 60 percent for comfort control or to prevent condensation on terminal units or outlets or functioning of special equipment.

(c) **New Energy for Temperature Control.** New energy may be used for temperature control if minimized in accordance with paragraphs (1) through (5).

1. **Reheat Systems.** Systems employing reheat and serving multiple zones, other than those employing variable air volume for temperature control, shall be provided with control that will automatically reset the system cold air supply to the highest temperature level that will satisfy the zone requiring the coolest air. Single zone reheat systems shall be controlled to sequence reheat and cooling.
2. **Dual Duct and Multi-Zone Systems.** These systems shall be provided with control that will automatically reset:
 - a the cold deck air supply to the highest temperature that will satisfy the zone requiring the coolest air, and
 - b the hot deck air supply to the lowest temperature that will satisfy the zone requiring the warmest air.
3. **Recooling Systems.** Systems in which heated air is recooled, directly or indirectly, to maintain space temperature shall be provided with control that will automatically reset the temperature to which the supply air is heated to the lowest level that will satisfy the zone requiring the warmest air.
4. **Multiple Zones.** For systems with multiple zones, one or more zones may be chosen to represent a number of zones with similar heating/cooling characteristics. A multiple zone HVAC system that employs reheating or recooling for control of not more than 5,000 cubic feet/min., or 20 percent of the total supply air of the system, whichever is less, shall be exempt from the supply air temperature reset requirement of paragraph 503.3(c)1. through 503.3(c)3.
5. **Concurrent Operation.** Concurrent operation of independent heating and cooling systems serving common spaces and requiring the use of new energy for heating or cooling shall be minimized by one or both of the following:
 - a By providing sequential temperature control of both heating and cooling capacity in each zone.
 - b By limiting the heat energy input through automatic reset control of the heating medium temperature (or energy input rate) to only that necessary to offset heat

loss due to transmission and infiltration and, where applicable, to heat the ventilation air supply to the space.

503.4 HVAC EQUIPMENT PERFORMANCE REQUIREMENTS

(a) Equipment and Components.

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 shown in Table 5-9.
2. Where components from more than one manufacturer are assembled into systems regulated under this section, compliance shall be shown as specified in paragraphs 503.4(b) through 503.4(g).

(b) HVAC System Heating Equipment Heat Pump-Heating Mode.

Heat pumps whose energy input is entirely electric shall show a coefficient of performance (COP) heating, not less than the values shown in Table 5-4.

1. These requirements apply to, but are not limited to, unitary heat pumps (air source and water source) in the heating mode and to heat pumps in the packaged terminal air conditioner and room air conditioner forms in the heating mode.
2. Coefficient of Performance (COP) Heating: The ratio of the rate of net heat output to the rate of total energy input, expressed in consistent units and under designated rating conditions.

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

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

3. **Supplementary Heater:** The heat pump shall be installed with a control to prevent supplementary heater operation when the heating load can be met by the heat pump alone.

Supplementary heater operation is permitted during transient periods, such as start-ups, following room thermostat set-point advance and during defrost.

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 of electric resistance heating or combustion heating.

- (c) **HVAC-System Combustion Heating Equipment.** All gas and oil fired comfort heating equipment shall show a minimum combustion efficiency of 75 percent at maximum rated output. Combustion efficiency is defined as 100 percent minus stack losses in percent of heat input. Stack losses are:
 1. loss due to sensible heat in dry fuel gas,
 2. loss due to incomplete combustion, and
 3. loss due to sensible and latent heat in moisture formed by combustion of hydrogen in the flue.
- (d) **Mechanical Ventilation.** Each mechanical supply and exhaust ventilation system shall be equipped with a readily accessible means for either shut-off or volume reduction and shut-off when ventilation is not required.
- (e) **HVAC-System Equipment, Electrically Operated, Cooling Mode.** HVAC-system equipment as listed below, whose energy input in the cooling mode is entirely electric, shall show a Coefficient of Performance (COP) - cooling not less than values shown in Table 5-5.
 1. These requirements apply to, but are not limited to, unitary cooling equipment (air-cooled, water-cooled and evaporatively-cooled); the cooling mode of unitary heat pumps (air source and water source); packaged terminal air conditioners.

EXCEPTION: These requirements do not apply to equipment used in areas having open refrigerated food display cases.

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

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

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

- (f) Applied HVAC-System Components, Electrically Operated, Cooling Mode. HVAC-system components, as listed in Table 5-6, whose energy input is entirely electric, shall show a Coefficient of Performance (COP) cooling not less than the values shown in Table 5-6.

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

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

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

- (g) HVAC-System Equipment - Heat Operated, Cooling Mode. Efficiency Limitation, Equipment: Heat-operated cooling equipment shall show a (COP) - cooling not less than the values shown in Table 5-7. These requirements apply to, but are not limited to, absorption equipment, engine driven equipment and turbine driven equipment.

1. Coefficient of Performance (COP): The ratio of the total net cooling output to the total heating input (electrical auxiliary inputs excluded).

503.5 ENERGY FOR AIR DELIVERY

The air transport factor for each all-air HVAC system shall not be less than 4.0. The factor shall be based on design system air flow for constant volume systems. The factor for variable air volume systems may be based on average conditions of operation. Energy for transfer of air through heat recovery devices shall not be included in determining the factor; however, such energy shall be included in the evaluation of the effectiveness of the heat recovery system.

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

*Expressed in Btu/h

503.6 BALANCING

The HVAC system design shall provide means for balancing the air and water systems including, but not 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 and dry-bulb temperature jointly or outdoor air dry-bulb temperature alone or alternate means approved by the Building Official.

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

- 1 Fan system capacity less than 5,000 cubic feet/min. or 134,000 Btu/h total cooling capacity.
- 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 it conserved by the outdoor air cooling.

- 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 Internal/external zone heat recovery or other energy recovery is used.
- 6 Annual heating degree days are less than 2500.
- 7 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 the use of a refrigeration system.

503.8 CONTROLS

- (a) Temperature Control. Each HVAC system shall be provided with at least one adjustable thermostat for the regulation of temperature. Each thermostat shall be capable of being set as follows:
 1. Where used to control heating only, a maximum temperature setting of 75F.
 2. Where used to control cooling only, a minimum temperature setting of 70F.
 3. Where used to control both heating and cooling, it shall have a maximum heating mode temperature setting of 75F and a minimum cooling mode temperature setting of 70F and shall be capable of operating the system heating and cooling in sequence. It shall be adjustable to provide a temperature range of up to 10F between full heating and full cooling, except as allowed in 503.3(c)5b.
- (b) Humidity Control. If an HVAC system is equipped with a means for adding moisture to maintain specific selected relative humidities in space or zones, a humidistat shall be provided. This device shall be capable of being set to prevent new energy from being used to produce space relative humidity above 30 percent relative humidity. Where a humidistat is used in a HVAC system for controlling moisture removal to maintain specific selected relative humidities in spaces or zones, it shall be capable of being set to prevent new energy

from being used to produce a space relative humidity below 60 percent relative humidity.

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

(c) Zoning For Temperature Control.

1. One- and Two-Family Dwellings. At least one thermostat for regulation of space temperature shall be provided for each separate HVAC system. In addition, a readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each zone or floor.
2. Multi-Family Dwellings. For multi-family dwellings, each individual dwelling unit shall be considered separately and shall meet the above requirements. Spaces other than living units shall meet the requirements of Section 503.8(c)3.
3. All Other Types of Buildings or Occupancies. At least one thermostat for regulation of space temperature shall be provided for:
 - a Each separate HVAC system.
 - b Each separate zone as defined in Section 2. As a minimum, each floor of a building shall be considered as a separate zone. In a multi-story building, where the perimeter system offsets only the transmission losses of the exterior wall, an entire side of uniform exposure may be zoned separately. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each floor.
4. Control Setback and Shut-off.
 - a Residential Occupancy Groups: One- and Two-Family and Multi-Family Dwellings - The thermostat required in 503.8(c)1 and 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 non-use 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 HVAC system shall be equipped with a readily accessible means of shutting off or reducing the energy used for HVAC during periods of non-use or alternate uses of the building spaces or zones served by the system. Acceptable means include, but are not limited to:

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

503.9 AIR HANDLING DUCT SYSTEM INSULATION

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

- (a) All duct systems, or portions thereof, shall be insulated to provide a thermal resistance, excluding film resistances, of:

$$R = \frac{\Delta t}{15} (h)(F)(ft^2)/Btu$$

where Δt = the design temperature differential between the air in the duct and the surrounding air in F.

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

- 1 Where Δt is 25F or less.
- 2 Supply or return air ducts installed in unventilated crawl spaces with insulated walls, basements or cellars in one- and two-family dwellings.
- 3 When the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building.
- 4 Within HVAC equipment.
- 5 Exhaust air ducts.

- (b) Additional insulation with vapor barriers shall be provided to prevent condensation.

EXCEPTION: May be omitted when it can be shown that condensation is not a problem.

503.10 DUCT CONSTRUCTION

All duct work shall be constructed and erected in accordance with Standards RS-15, RS-16, RS-17, RS-18, RS-19 or RS-20, as applicable (the Mechanical Code of the jurisdiction).¹

- (a) High-pressure and medium pressure ducts shall be leak tested in accordance with the applicable Reference Standards in Section 7 of the Code 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, except those located within return air plenums, all transverse joints shall be sealed using mastic or mastic plus tape. For fibrous glass duct-work, pressure sensitive tape may be used.
- (c) Automatic or manual dampers installed for the purpose of shutting off outside air intakes for ventilation air shall be designed with tight shut-off characteristics to minimize air leakage.

503.11 PIPING INSULATION

All piping installed to service buildings and within buildings shall be thermally insulated in accordance with Table 5-8, except as stated herein. (For service water heating systems see Section 504.0.)

- (a) Other Insulation Thickness. Insulation thickness in Table 5-8 is based on insulation having thermal resistance in the range of $4.0 \text{ h F ft}^2/\text{Btu}$ to $4.6 \text{ h F ft}^2/\text{Btu}$ per inch of thickness on a flat surface at a mean temperature of 75F. Minimum insulation thickness shall be increased for materials having R values less than 4.0, or may be reduced for materials having R values greater than 4.6 as follows:

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

¹Optional provision may be used by agencies that have adopted a mechanical code that includes equivalent duct construction standards. See Item IV of Foreword.

$$\frac{4.6 \times \text{Table 5-8 Thickness}}{\text{Actual R}} = \text{New Minimum Thickness}$$

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

$$\frac{4.0 \times \text{Table 5-8 Thickness}}{\text{Actual R}} = \text{New Minimum Thickness}$$

EXCEPTIONS: Piping insulation is not required in any of the following cases:

- 1 Piping installed within HVAC equipment.
- 2 Piping at temperatures between 55F and 120F when not required for energy conservation purposes.
- 3 When the heat loss and/or heat gain of the piping, without insulation, does not increase the energy requirements of the building.
- 4 Piping, installed in unventilated crawl spaces with insulated walls and basements or cellars in one- and two-family dwellings.

- (b) Additional insulation with vapor barriers shall be provided to prevent condensation.

EXCEPTION: May be omitted when it can be shown that condensation is not a problem.

504.0 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, BOILERS, AND PIPING

(a) Performance Efficiency.

1. Electric Storage Water Heaters. All automatic electric storage water heater(s) shall have a stand-by loss not exceeding 4.0 watts/ft^2 of tank surface area when tested in accordance with Std RS-6.

TABLE 5-4
MINIMUM COP FOR HEAT PUMPS, HEATING MODE¹

SOURCE AND OUTDOOR TEMPERATURE (F)	MINIMUM COP
Air Source - 47 dB/43WB	2.2
Air Source - 17 dB/15WB	1.2
Water Source - 60 Entering	2.2

¹When tested at the Standard Rating specified in Table 5-9A.

TABLE 5-5 - MINIMUM EER AND COP
FOR ELECTRICALLY DRIVEN HEATING, VENTILATING AND
AIR CONDITIONING SYSTEM EQUIPMENT - COOLING¹

STANDARD RATING CAPACITY	EER	COP
Under 65,000 Btu/h (19,050 watts)	6.1	1.8
65,000 Btu/h (19,050 watts and over)	6.8	2.0

¹When tested at the Standard Rating Conditions specified in Table 5-9B.

TABLE 5-6 - MINIMUM EER AND COP
FOR ELECTRICALLY DRIVEN HEATING, VENTILATING AND
AIR CONDITIONING SYSTEM COMPONENTS¹

COMPONENT	CONDENSING MEANS	AIR		WATER		EVAPORATOR	
		EER	COP	EER	COP	EER	COP
	Centrifugal	7.5	2.2	12.9	3.8		
Self-contained Water Chillers	Positive Displacement	7.2	2.1	10.9	3.2		
Condenserless Water Chillers	Positive Displacement	8.9	2.6	10.9	3.2		
Compressor and Condenser Units 65,000 Btu/h (19,050 watts and over) ²	Positive Displacement	7.8	2.3	11.3	3.3	11.3	11.3

¹When tested at the Standard Rating Conditions specified in Table 5-9C.

²Ratings in accordance with Std RS-14 as applicable. COP based on condensing unit Standard Rating Capacity and energy input to the unit, all at sea level.

TABLE 5-7 - MINIMUM COP
FOR HEATING, VENTILATING AND AIR
CONDITIONING SYSTEM HEAT OPERATED
COOLING EQUIPMENT

HEAT SOURCE	MINIMUM COP
Direct fired (gas, oil)	0.40
Indirect fired (steam, hot water)	0.65

TABLE 5-8
MINIMUM PIPE INSULATION

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGE, F	INSULATION THICKNESS IN INCHES FOR PIPE SIZES					
		RUN-OUTS UP TO 2"1	1" AND LESS	1½ to 2"	2½ to 4"	5" to 6"	8" AND LARGER
HEATING SYSTEMS							
Steam and Hot Water							
High Pressure/Temp	306-450	1½	1½	2	2½	3½	3½
Med. Pressure/Temp	251-305	1½	1½	2	2½	3	3
Low Pressure/Temp	201-250	1	1	1½	1½	2	2
Low Temperature	120-200	½	¾	1	1	1	1½
Steam Condensate (for Feed Water)	Any	1	1	1	1½	1½	2
COOLING SYSTEMS							
Chilled Water	40-55	½	½	¾	1	1	1
Refrigerant, or Brine	Below 40	1	1	1½	1½	1½	1½

¹Runouts not exceeding 12' in length to Individual Terminal Units.

TABLE 5-9A
HVAC SYSTEM Heating Equipment (Heat Pumps)
Standard Rating Conditions

		AIR SOURCE		WATER SOURCE
CONDITIONS	TYPE			
Air Entering Equipment	F	70 db	70 db	70 db
Outdoor Unit Ambient	F	47 db/43 wb	17 db/15 wb	--
Entering Water Temperature	F	--	--	60
Water Flow Rate		--	--	as used in cooling mode

TABLE 5-9 B
HVAC SYSTEM Equipment
Standard Rating Conditions - Cooling

		TEMPERATURES			
		DB	WB	INLET	OUTLET
Air Entering Equipment	F	80	67	-	-
Condenser Ambient (Air Cooled)	F	95	75	-	-
Condenser Water (Water Cooled)	F	-	-	85	95

Standard Ratings are at sea level.

TABLE 5-9 C
Applied HVAC System Components
Standard Rating Conditions - Cooling

Item		Centrifugal or Self-Contained Reciprocating Water-Chiller	Condenserless Reciprocating Water-Chiller
Leaving Chilled Water Temp	F	44	44
Entering Chilled Water Temp	F	54	54
Leaving Condenser Water Temp	F	95	--
Entering Water Temp	F	85	--
Non-Ferrous Tubes	*	0.0005	0.0005
Fouling Factor, Water	*		
Steel Tubes	*	0.0010	0.0010
Fouling Factor, Refrigerant	*	0.0000	0.0000
Condenser Ambient (Air or Evap. Cooled)	F	95 db/75 wb	--
Compressor Saturated	Water Cooled (or Evap. Cooled) F	--	105
Discharge Temp	Air Cooled F	--	120

Standard Ratings are at sea level
 *h ft² F/Btu

2. Gas and Oil Fired Storage Water Heaters. All gas and oil fired, automatic storage water heaters shall have a recovery efficiency (E_r) not less than 75 percent and stand-by loss percentage (S) not exceeding:

$$S = 2.3 + 67/V$$

where

V = rated volume in gallons

when tested in accordance with Std RS-7.

EXCEPTION: In utilizing Std RS-7 to test oil fired units $CF = 1.0$; Q equals total gallons of oil consumed; and H equals total heating value of oil in Btu/gal.

3. Insulation. Heat loss from unfired hot water storage tanks shall be limited to a maximum of 15 Btu/h $\cdot$ ft² of external tank surface area. The design ambient temperature shall be no higher than 65F.
4. Combination Service Water Heating/Space Heating Boilers. Service water heating equipment shall not be dependent on year round operation of space heating boilers; (that is, boilers that have as another function winter space heating).

EXCEPTION: Exempt from these requirements are systems with service/space heating boilers having a stand-by loss Btu/h less than:

$$\frac{13.3 \text{ pmd} + 400}{n}$$

pmd = probable maximum demand in gallons/hour as determined in accordance with Chapter 11 of Std RS-11.

n = fraction of year when outdoor daily mean temperature exceeds 64.9F.

The stand-by loss is to be determined for a test period of 24 h duration while maintaining a boiler water temperature of 90F above ambient.

(b) Temperature Controls.

1. 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 Chapter 37, Table 1 of Std RS-11.

2. Shut down. A separate switch shall be provided to permit turning off the energy supplied to electric service water heating systems. A separate valve shall be provided to permit turning off the energy supplied to the main burner(s) of all other types of service water heating systems.

3. Swimming Pools.

- a Heated swimming pools shall be equipped with controls to limit heating water temperatures to no more than 80F.

EXCEPTION: Pools used for therapeutic purposes are exempt from this requirement when approved by the Building Official.

- b Uncovered or unenclosed heated pools shall be controlled so that the electric or fossil-fueled pool water heating systems are inoperative whenever the outdoor air temperature is below 60F.

504.3 PUMP OPERATION

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

504.4 PIPE INSULATION

For recirculation systems, piping heat loss shall be limited to a maximum of 25 Btu/h ft² of external pipe surface for above ground piping and a maximum of 35 Btu/h ft² of external pipe surface for underground piping. Maximum heat loss shall be determined at a Δt equal to the maximum water temperature minus a design ambient temperature no higher than 65F.

504.5 CONSERVATION OF HOT WATER

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

(b) Lavatories in Restrooms of Public Facilities shall:

1. Be equipped with outlet devices which limit the flow of hot water to a maximum of 0.5 gpm.
2. Be equipped with devices which limit the outlet temperature to a maximum of 110F.
3. Be equipped with self closing valves that limit delivery to a maximum of 0.25 gallons of hot water.

505.0 ELECTRICAL POWER AND LIGHTING

505.1 GENERAL

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

505.2 ELECTRICAL DISTRIBUTION

- (a) Power Factor. Utilization equipment, rated greater than 1,000W and lighting equipment greater than 15W, with an inductive reactance load component, shall have a power factor of not less than 85 percent under rated load conditions. Power factor of less than 85 percent shall be corrected to at least 90 percent under rated load conditions. Power factor corrective devices, installed to comply with this Code, shall be switched with the utilization equipment, except where this results in an unsafe condition or interferes with the intended operation of the equipment.
- (b) Service Voltage. Where a choice of service voltages is available, a computation shall be made to determine which service voltage would produce the least energy loss, and that voltage shall be selected.
- (c) Voltage Drop. In any building, the maximum total voltage drop shall not exceed 3 percent in branch circuits or feeders, for a total of 5 percent to the farthest outlet based on steady state design load conditions.
- (d) Lighting Switching. Switching shall be provided for each lighting circuit, or for portions of each circuit, so that the partial lighting required for custodial or for effective com-

plementary use with natural lighting may be operated selectively.

- (e) **Electrical Energy Determination.** In all multi-family dwellings, provision shall be made to determine the energy consumed by each tenant by separately metering individual dwelling units.

EXCEPTION: Motels, hotels, and dormitories are exempt from these requirements.

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

EXCEPTION: One- and two-family detached dwellings and the dwelling portion of multi-family buildings are exempt from the requirements of Section 505.3.

(a) Calculation Methods,

1. The criteria specified below shall be utilized for computation of the lighting power budget. All calculations shall be in accordance with Section 505.3(e), Calculation Procedure.
2. When insufficient information is known about the specific use of the building space (e.g., number of occupants, space function, location of partitions), the budget shall be based on the apparent intended use of the building space.

(b) Building Interiors.

The allowable electric power for lighting shall be established by using the criteria and the calculation procedures specified in Section 505.3(e). The value shall be based on the use for which the space within the building is intended.

1. **Illumination Level Criteria.** For the purpose of establishing a budget, levels of illumination shall be those listed in Standard RS-8. Those levels shall be used as follows:

- a Task Lighting. In most cases, the levels of illumination listed are for specific tasks. These levels are for the task areas defined in Standard RS-8, or, where not defined, at all usable portions of task surfaces. In some cases, the levels of illumination are listed for locations. These levels are to be considered as average levels.
- b General Lighting. In areas surrounding task locations, the average level of general lighting, for budget purposes only, shall be one-third the level for the tasks performed in the area but in no case less than 20 footcandles. Where more than one task level occurs in a space, the general level shall be one-third the weighted average of the specific task levels.
- c Non-Critical Lighting. In circulation and seating areas where no specific visual tasks occur, the average level of illumination shall be one-third of the average general lighting in the adjacent task spaces but in no case less than 10 footcandles.
- d Lighting System Criteria. For the purposes of establishing a power budget, only lamp efficacies and coefficients of utilization (CU), specified in Table 5-10, shall be assumed.

(c) Exceptions to Building Interior Criteria.

1. The criteria of Section 505.3(b) shall not apply to the following areas when calculating the load.
 - a Residential type spaces in institutions, such as hospitals, hotels, funeral homes, churches, museums, etc., other than kitchens, bathrooms, laundry areas and public spaces, including lobbies, halls, stairways, basement areas and utility rooms.
 - b Theatre auditoriums, entertainment, audio-visual presentations and motion picture and television studios where the lighting is an essential technical element for the function performed.
2. The criteria of 505.3(b)1.d shall not apply to the following lamps and luminaires; however, their use shall be accounted for in the calculation of task lighting loads for specific tasks. The allowable load shall be based on the luminaire

wattage to achieve the levels of illumination as covered in 505.3(b) using a point calculation method given in Standard RS-8.

- a Luminaires for medical and dental purposes.
 - b Luminaires for highlighting applications, such as sculpture exhibits, art exhibits, and individual items of display merchandise.
 - c Luminaires for specialized lighting applications (color matching, where electrical interference cannot be tolerated, etc.).
3. The criteria of Table 5-10(C) shall not apply in spaces where it is impractical to control reflectances and where a dirty atmosphere cannot be avoided. Where this condition exists, the values for reflectances and light loss factors shall be those expected to be found and shall be approved by the Building Official. The calculation shall make note of this deviation.

(d) Building Exteriors.

In exterior spaces, the lighting power budget shall be based on the use for which the space is intended.

1. Criteria. The same criteria as those for interior spaces apply for illumination levels and lighting systems with the addition of luminaires for floodlighting. For power budget purposes luminaires shall have a greater percentage of their beam lumens restricted to the area to be lighted and have minimum efficiencies at least as great as those listed in Standard RS-8.
2. Facade Lighting. Facade lighting for budget purposes shall be no greater than 2 percent of the total interior load of the building.
3. Calculation Procedure. In establishing a lighting power budget the following procedures shall be used:
 - a Overhead Lighting. The procedure specified in Section 505.3(e) shall be followed for overhead lighting, but using reflectances as found.
 - b Floodlighting. The beam lumen method, as shown in

Standard RS-8 and a coefficient of beam utilization (CBU) of 0.75 shall be used for floodlighting calculations.

(e) Calculation Procedure.

To establish a lighting power budget, the following procedure shall be used:

1. Determining Illumination Levels and Areas:

- a Determine the visual tasks that are expected to be performed in each space (the commonly found tasks at each work station) and the number of planned work locations where tasks will be performed. If assumptions are made, their bases shall be indicated.
- b Select the illumination level, in footcandles for those expected tasks in accordance with Section 505.3(b)1.a.
- c Calculate total task areas to be illuminated to the same level by multiplying the number of work locations by 50 ft² per work location. (Total task area shall not exceed actual total space area.) If actual task area is greater than 50 ft² actual area shall be used. If special task lighting or localized lighting is to be employed, use the actual task areas and point calculation procedures.
- d Calculate the level of general lighting by multiplying the task lighting level by one-third, where there is only one task level, or by taking one-third of the sum of the products of the task levels (b) and their areas (c) divided by the total task areas in accordance with Section 505.3(b)1.b.
- e Calculate the level of non-critical lighting in accordance with Section 505.3(b)1.c.
- f For area determinations of general and non-critical lighting, calculations shall be based on Standard RS-9, B-3.b, Attachment B.

2. Determining Lighting System Data:

- a Determine light source and luminaire types to use.
- b Determine lamp lumens per watt and luminaire coefficients

of utilization for room luminaire mounting height dimensions. Luminaire CUs shall be selected from Std RS-8 or manufacturers' data for types not found in Std RS-8. In all cases, no luminaire shall have a CU for $RCR = 1$ or less than that given in Table 5-10 B. Lamp efficacies shall be those listed in Table 5-10 A.

3. Determining Allowable Wattage:

- a Using data from (e)2. above, the illumination levels and areas determined in (e)1. and the criteria of Table 5-10 C, calculate the allowable wattages using the lumen method.
- b Calculate the total space wattage by adding the task, general and non-critical lighting loads.
- c Add the wattage of luminaires allowed in 505.3(c)2.

TABLE 5-10 A

LAMP EFFICACIES

Application	Lumens per Watt
Where moderate color rendition is appropriate	55
Where good color rendition is appropriate	40
Where high color rendition is appropriate, spaces are less than 50 ft ² or where use of low wattage High Intensity Discharge (HID) lamps under 250 W or fluorescent lamps under 40 W is appropriate	25

¹The initial lumen output per watt input, including ballast losses.

TABLE 5-10 B

LUMINAIRE COEFFICIENTS OF UTILIZATION (CU)¹

Space Use	Minimum CU (at RCR = 1)
For spaces with tasks subjected to veiling reflections (where design levels of illumination are listed in terms of equivalent sphere illumination (ESI) and where visual comfort is important.	0.55
For spaces without tasks, or with tasks not subjected to veiling reflections, but where visual comfort is important.	0.63
For spaces without tasks and where visual comfort is not a criterion.	0.70

¹Coefficients of utilization (CU's) are to be for luminaires for use in the types of spaces listed, and those luminaires shall have a CU of no less than that listed for each type space for a Room Cavity Ratio (RCR) of 1 and reflect areas as in Table 5-10C.

TABLE 5-10 C

REFLECTANCES & LIGHT LOSS FACTORS

INTERIOR SPACES ¹	REFLECTANCE	LIGHT LOSS FACTOR
Ceiling Cavity	80 percent	0.70
Wall	50 percent	
Floor Cavity	20 percent	

¹For interior spaces, initial cavity and surface reflectances shall be shown.

SECTION 6 - BUILDING DESIGN BY ACCEPTABLE PRACTICE

601.0 SCOPE

601.1 GENERAL

The requirements contained in this section are applicable only to buildings less than five thousand square feet in gross floor area and three stories or less in height. The provisions of this section are limited to residential buildings that are heated or mechanically cooled and to other buildings that are heated only. Buildings constructed in accordance with this section are deemed to comply with this Code.

602.0 BUILDING ENVELOPE REQUIREMENTS

602.1 GENERAL

The various wall, roof and floor assemblies in Appendix Tables 6-1A, B and C, 6-2 and 6-3 are typical and are not intended to be all inclusive. Other assemblies may be used provided documentation is submitted indicating the thermal transmittance value of the opaque section. Such documentation shall be in accordance with accepted engineering practice.

The proposed design may take into consideration the thermal mass of the building when considering energy conservation, when approved by Building Official.

602.2 CRITERIA - HEATING AND COOLING

- (a) Walls. The combined thermal transmittance value (U_o) of the exterior walls shall not exceed the value specified in Table 5-1 or 5-2 as appropriate for the building type. The U_o of the wall shall be determined by selecting the U_w value for the wall section from Appendix Table 6-1A, B or C and modifying the U_w by the use of Chart 6-A or 6-B based on the glazing area.
- (b) Roof/Ceiling. The roof/ceiling assembly shall be selected from Appendix Table 6-2 for thermal transmittance value not exceeding the value specified for roof/ceiling in Table 5-1 or 5-2 as appropriate for the building type.
- (c) Floors over Unheated Spaces. The floor section over an unheated space shall be selected from Appendix Table 6-3 for the thermal transmittance value (U_o value) not exceeding the value

specified for floors in Table 5-1 or 5-2 as appropriate for the building type.

- (d) Slab on Grade floors. For slab on grade floors, thermal resistance (R) of the insulation around the perimeter of the floor shall not be less than the value given in Table 5-1 or 5-2 as appropriate for the building type.

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.

602.3 AIR LEAKAGE

- (a) Windows and Doors. All windows and doors shall conform to Section 502.4 (b).
- (b) Caulking. Exterior joints around windows and door frames; openings between walls and foundations, between walls and roof and between wall panels; openings at penetrations of utility services through walls, floors and roofs; and all other such openings in the building envelope shall be caulked, gasketed, weatherstripped, or otherwise sealed in an approved manner.

603.0 BUILDING MECHANICAL SYSTEMS

603.1 GENERAL

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

Systems other than combustion heating equipment and unitary cooling and heating equipment regulated from a single point of control shall be designed in accordance with the requirements of Section 5 of this Code.

603.2 HVAC EQUIPMENT PERFORMANCE REQUIREMENTS

- (a) Heating and Mechanical Cooling Equipment Performance. The requirements of this section apply to equipment and mechanical component performance. Equipment shall be rated in accordance with Section 503.4(a). All heating and mechanical cooling equipment shall meet the required efficiency factor specified herein or in Tables 6-4, 6-5, 6-6 and 6-7, for the specific type of device.

(b) Combustion Heating Equipment. All gas and oil fired comfort heating equipment shall show a minimum combustion efficiency of 75 percent at maximum rated output. Combustion efficiency is defined as 100 percent minus stack losses in percent of heat input. Stack losses are:

1. loss due to sensible heat in dry flue gas,
2. loss due to incomplete combustion, and
3. loss due to sensible and latent heat in moisture formed by combustion of hydrogen in the flue.

603.3 CONTROLS

(a) Temperature Control. Each heating system shall be provided with at least one adjustable thermostat for the regulation of temperature. Each thermostat shall be capable of being set as follows:

1. Where used to control heating only, a maximum temperature setting of 75F.
2. Where used to control cooling only, a minimum temperature setting of 70F.
3. Where used to control both heating and cooling, thermostat shall be in accordance with Section 503.8(a)3.

(b) Zoning for Temperature Control.

1. One- and Two-family Dwellings. At least one thermostat for regulation of space temperature shall be provided for each separate HVAC system. In addition, a readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating or cooling input to each zone or floor.
2. Multi-family Dwellings. For multi-family dwellings, each individual dwelling unit shall be considered separately and shall meet the requirements of Section 603.1(b)1. Spaces other than living units shall meet the requirements of Section 503.8(c)3.
3. Control Setback and Shutoff. One- and Two-family and Multi-family Dwellings. The thermostat required in 1 and 2 above, or an alternate means such as a switch or clock,

shall provide a readily accessible manual or automatic means for reducing the energy required for heating and cooling during periods of non-use or reduced need 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.

603.4 AIR HANDLING DUCT SYSTEM INSULATION

All ducts, plenums and enclosures installed in or on buildings shall be thermally insulated and constructed in accordance with Section 503.10.

603.5 PIPING INSULATION

All piping installed to serve buildings or within buildings shall be thermally insulated in accordance with Table 6-8, except as stated in Section 503.11.

604.0 SERVICE WATER HEATING

604.1 SERVICE WATER HEATING

Water heating storage tanks, boilers and piping for all water heating systems shall be installed in accordance with Section 504.2.

(a) Performance Efficiency. Water heaters shall be labeled as meeting the efficiency requirements of Section 504.2(a).

(b) Temperature Controls.

1. Service water heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use.
2. Shut-down. A separate switch shall be provided to permit turning off the energy supplied to electric service water heating systems. A separate valve shall be provided to permit turning off the energy supplied to the main burner(s) of all other types of service water heating systems.

3. Swimming Pools.

- a Heated swimming pools shall be equipped with controls to limit heating water temperatures to no more than 80F.

EXCEPTIONS: Pools used for therapeutic purposes are exempt from this requirement when approved by the Building Official.

- b Uncovered or unenclosed heated pools shall be controlled so that the electric or fossil-fueled pool water heating systems are inoperative whenever the outdoor air temperature is below 60F.

604.2 PUMP OPERATION

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

604.3 PIPE INSULATION

For recirculating systems piping heat loss shall be limited to a maximum of 25 Btu/h ft² of external pipe surface for above ground piping and a maximum of 35 Btu/h ft² of external pipe surface for underground piping. Maximum heat loss shall be determined at a Δt equal to the maximum water temperature minus a design ambient temperature of no higher than 65F.

604.4 CONSERVATION OF HOT WATER

- (a) Showers used for other than safety reasons shall be equipped with flow control devices to limit total flow to a maximum of 3 gpm per shower head.
- (b) Lavatories in restrooms of public facilities shall conform to the requirements of Section 504.5(b).

605.0 ELECTRICAL POWER AND LIGHTING

The electrical power distribution and lighting systems shall conform to the requirements of Sections 505.2 and 505.3.

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

TABLE 6-4
MINIMUM COP FOR HEAT PUMPS, HEATING MODE¹

SOURCE AND OUTDOOR TEMPERATURE (F)	MINIMUM COP
Air Source - 47 dB/43WB	2.2
Air Source - 17 dB/15WB	1.2
Water Source - 60 Entering	2.2

¹When tested at the Standard Rating specified in Table 5-9A.

TABLE 6-5 - MINIMUM EER AND COP
FOR ELECTRICALLY DRIVEN HEATING, VENTILATING AND
AIR CONDITIONING SYSTEM EQUIPMENT - COOLING¹

STANDARD RATING CAPACITY	EER	COP
Under 65,000 Btu/h (19,050 watts)	6.1	1.8
65,000 Btu/h (19,050 watts and over)	6.8	2.0

¹When tested at the Standard Rating Conditions specified in Table 5-9B.

TABLE 6-6 - MINIMUM EER AND COP
FOR ELECTRICALLY DRIVEN HEATING, VENTILATING AND
AIR CONDITIONING SYSTEM COMPONENTS¹

COMPONENT	CONDENSING MEANS	AIR		WATER		EVAPORATOR	
		EER	COP	EER	COP	EER	COP
	Centrifugal	7.5	2.2	12.9	3.8		
Self-contained Water Chillers	Positive Displacement	7.2	2.1	10.9	3.2		
Condenserless Water Chillers	Positive Displacement	8.9	2.6	10.9	3.2		
Compressor and Condenser Units 65,000 Btu/h (19,050 watts and over) ²	Positive Displacement	7.8	2.3	11.3	3.3	11.3	11.3

¹When tested at the Standard Rating Conditions specified in Table 5-9C.

²Ratings in accordance with Std RS-14 as applicable. COP based on condensing unit Standard Rating Capacity and energy input to the unit, all at sea level.

**TABLE 6-7 - MINIMUM COP
FOR HEATING, VENTILATING AND AIR
CONDITIONING SYSTEM HEAT OPERATED
COOLING EQUIPMENT**

HEAT SOURCE	MINIMUM COP
Direct fired (gas, oil)	0.40
Indirect fired (steam, hot water)	0.65

**TABLE 6-8
MINIMUM PIPE INSULATION**

PIPING SYSTEM TYPES	FLUID TEMPER- ATURE RANGE, F	INSULATION THICKNESS IN INCHES FOR PIPE SIZES					
		RUN- OUTS UP TO 2" ¹	1" AND LESS	1½ to 2"	2½ to 4"	5" to 6"	8" AND LARGER
HEATING SYSTEMS							
Steam and Hot Water							
High Pressure/Temp	306-450	1½	1½	2	2½	3½	3½
Med. Pressure/Temp	251-305	1½	1½	2	2½	3	3
Low Pressure/Temp	201-250	1	1	1½	1½	2	2
Low Temperature	120-200	½	3/4	1	1	1	1½
Steam Condensate (for Feed Water)	Any	1	1	1	1½	1½	2
COOLING SYSTEMS							
Chilled Water	40-55	½	½	3/4	1	1	1
Refrigerant, or Brine	Below 40	1	1	1½	1½	1½	1½

¹Runouts not exceeding 12' in length to Individual Terminal Units.

Chart 6-A

U_w Values for Opaque Walls

Combinations of Wall and Single Glazed Openings for Use with Section 602.2(a)

¹One-Half the Opaque Door Area shall be Included in the Total Glazed Openings Area

Chart 6-B

U_w Values for Opaque Walls

Combinations of Wall and Double Glazed Openings for Use with Section 602.2(a)

¹The Total Area of Opaque Doors shall be Included in the Glazed Opening Area

SECTION 7 - STANDARDS

701.0 The Standards (Std), and portions thereof, which are referred to in various parts of this Code shall be part of the Model Code for Energy Conservation in New Building Construction and are hereby declared to be a part of this Code.

CODE STANDARD

NO.	TITLE AND SOURCE
RS-1	1972 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 the ASTM. Specifications for Aluminum Windows, ANSI A134.1, 1972 Specifications for Aluminum Sliding Glass Doors, ANSI A134.2, 1972. Industry Standard for Wood Window Units, NWMA IS-2, Industry Standard for Wood Sliding Patio Doors, NWMA IS-3.
RS-3	ASHRAE Standard 62-73 Natural and Mechanical Ventilation.
RS-4	ASHRAE Standard 55-74 Thermal Environmental Conditions for Human Occupancy.
RS-5	Reserved
RS-6	Household Automatic Electric Storage-Type Water Heaters, ANSI C72.1-72.
RS-7	Gas Water Heaters, Volume III, Circulating Tank, Instantaneous and Large Automatic Storage-Type Water Heaters, ANSI Z21.10.3-74.
RS-8	IES Lighting Handbook, 5th Edition, 1972 Illuminating Engineering Society.

RS-9	Charts & graphs modified to conform to the terminology of this Code from ASHRAE Standard 90-75, Energy Conservation in New Building Design.
RS-10	Standard for Packaged Terminal Air Conditioners, ARI Standard 310-70.
RS-11	1973 ASHRAE HANDBOOK AND PRODUCT DIRECTORY, SYSTEMS VOLUME.
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	1975 ASHRAE HANDBOOK AND PRODUCT DIRECTORY, EQUIPMENT VOLUME.
RS-16	Residential Heating and Air Conditioning Systems - Minimum Installation Standards, NESCA/SMACNA, August 1973.
RS-17	Low Velocity and Duct Construction Standards, 4th Edition, SMACNA, 1969.
RS-18	High Velocity Duct Construction Standards, 2nd Edition, SMACNA, 1969.
RS-19	Fibrous Glass Duct Construction Standards, 3rd Edition, SMACNA, 1972.
RS-20	Pressure Sensitive Tape Standards SMACNA, 1973.

ACCREDITED AUTHORATIVE AGENCIES

ANSI refers to the American National Standards Institute, Inc., 1430 Broadway, N.Y., 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., 345 East 47th Street, N.Y., NY 10017

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

IES refers to Illuminating Engineering Society, 345 East 47th Street, N.Y., 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., 1611 North Kent St., Suite 200, Arlington, VA 22209

Fig. 1

U_o WALLS—GROUP R BUILDINGS

TYPE R BUILDINGS SHALL INCLUDE:

A 1 DETACHED ONE AND TWO FAMILY DWELLINGS

A 2 ALL OTHER RESIDENTIAL BUILDINGS, THREE
STORIES OR LESS, INCLUDING BUT NOT LIMITED
TO:

MULTI-FAMILY DWELLINGS
HOTELS AND MOTELS

Fig. 2
R VALUES—SLAB ON GRADE

Fig. 3

U_o WALLS—HEATING

FOR ALL
BUILDINGS NOT REGULATED BY SECTION
502.2

Fig. 4

U_o —ROOFS AND CEILINGS

FOR ALL
BUILDINGS NOT REGULATED BY SECTION
502.2

Fig. 5

U_o VALUES—FLOORS OVER UNHEATED SPACES

Fig. 6

OVERALL THERMAL TRANSFER VALUE

WALLS COOLING

FOR ALL

BUILDINGS NOT REGULATED BY SECTION

502.2

Fig. 7

SOLAR FACTOR (SF) VALUES

APPENDIX

The construction sections in Tables 6-1A, 6-1B, 6-1C, 6-2 and 6-3 are intended to be representative and not all inclusive. Adopting agencies are encouraged to add construction sections appropriate to their specific areas.

Utilization of these tables should be correlated with local industry group practices and model code research recommendations.

WALL ASSEMBLIES
TABLE 6-1A

U_w SELECTED SHALL NOT EXCEED THE U_o DETERMINED
BY SECTION 602.2(a) FOR ANY WALL SECTION.

NOTE: DETAILS SHOWN ARE FOR INSULATION AND ARE NOT COMPLETE CONSTRUCTION DETAILS.

WALL DETAILS		R VALUE OF INSULATION	U _w
SCHEDULES			
TYP. INTERIOR FINISH 1.GYPSUM WALLBOARD 2.LATH & PLASTER 3.3/8"MIN.WD.PANELING	TYP. EXTERIOR FINISH 1.STUCCO 2.WD. OR PLYWD.SDG. 3.BRICK VENEER		
INTERIOR FINISH — — EXTERIOR FINISH INSULATION — — EXTERIOR FINISH SECTION	7	.12	
	11	.09	
	14	.07	
	19	.05	
AIR SPACE — — EXTERIOR FINISH INTERIOR FINISH — — RIGID INSULATION PLAN	4	.15	
	6	.11	
	8	.09	
	10	.08	
	12	.06	
INTERIOR FINISH — — EXTERIOR FINISH INSULATION — — EXTERIOR FINISH SECTION	7	.12	
	11	.08	
	14	.06	
	19	.05	
AIR SPACE OR INSULATION — — EXTERIOR FINISH INTERIOR FINISH — — INSULATION PLAN	4	.15	
	6	.11	
	8	.09	
	10	.08	
	12	.06	

WALL ASSEMBLIES
TABLE 6-1B

U_w SELECTED SHALL NOT EXCEED THE U_o DETERMINED
BY SECTION 602.2(a) FOR ANY WALL SECTION.

NOTE: DETAILS SHOWN ARE FOR INSULATION AND ARE NOT COMPLETE CONSTRUCTION DETAILS.

WALL DETAILS		R VALUE OF INSULATION	U_w
INT. FINISH - 1/2" GYPSUM BOARD ON FURRING STRIPS
	6" BLOCK	NO INSUL.	.37
		LOOSE FILL IN CORES	.18
	8" BLK.	NO INSUL.	.34
		LOOSE FILL IN CORES	.14
	4" BLOCK	NO INSUL. (NO INT. FINISH)	.25
		LOOSE FILL IN CAVITY	.14
		NO INSUL. WITH INT. FIN.	.19
		LOOSE FILL IN CAVITY WITH INT. FINISH	.11
		NO INSUL. INT. FINISH	.23
		LOOSE FILL IN CORES WITH INT. FINISH	.12
		1" RIGID GLASS FIBER INSUL. & INT. FINISH	.14
		R-7 INSUL. WITH INT. FINISH	.10

MASONRY CONSTRUCTION

WALL ASSEMBLIES
TABLE 6-1C

U_w SELECTED SHALL NOT EXCEED THE U_0 DETERMINED
BY SECTION 602.2(a) FOR ANY WALL SECTION.

NOTE: DETAILS SHOWN ARE FOR INSULATION AND ARE NOT COMPLETE CONSTRUCTION DETAILS.

WALL DETAILS		R VALUE OF INSULATION	U_w
INT. FINISH - 1/2" GYPSUM BOARD APPLIED ON FURRING STRIPS			
<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: right; margin-right: 10px;">BRICK</div> <div style="text-align: left; margin-left: 10px;">BRICK LOOSE FILL</div> </div>	SOLID GROUT IN SPACE		.38
	2" SPACE W/ LOOSE FILL R=4		.16
	4" SPACE W/ LOOSE FILL R=8		.10
<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: right; margin-right: 10px;">BRICK</div> <div style="text-align: left; margin-left: 10px;">INTERIOR FINISH INSULATION</div> </div>	4		.12
	6		.09
	7		.09
	11		.07
<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: right; margin-right: 10px;">4" Min. NORMAL WT. CONCRETE</div> <div style="text-align: left; margin-left: 10px;">INTERIOR FINISH INSULATION</div> </div>	4		.18
	6		.13
	7		.12
	11		.08
<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: right; margin-right: 10px;">4" Min. LT.WT. CONCRETE</div> <div style="text-align: left; margin-left: 10px;">INTERIOR FINISH INSULATION</div> </div>	4		.17
	6		.12
	7		.11
	11		.08

ROOF/CEILING ASSEMBLIES
TABLE 6-2

U_r SELECTED SHALL NOT EXCEED THE
VALUE SPECIFIED IN 602.2(b).

NOTE: DETAILS SHOWN ARE FOR INSULATION AND ARE NOT COMPLETE CONSTRUCTION DETAILS.

ROOF DETAILS	R VALUE OF INSULATION	U_r
TYPICAL INTERIOR FINISH SCHEDULE 1. GYPSUM WALLBOARD 2. LATH & PLASTER
	11	.09
	14	.07
	19	.05
	22	.04
	30	.03
	11	.08
	14	.06
	19	.05
	22	.04
	30	.03
CATHEDRAL TYPE CEILING	wood decking 9	.08
	plywood 10	.08

1. SKYLITES NOT EXCEEDING ONE PERCENT OF THE ROOF AREA ARE PERMITTED.

FLOOR ASSEMBLIES
TABLE 6-3

U_f SELECTED SHALL NOT EXCEED THE U_o SPECIFIED IN SECTION 602.2(c).

FLOOR DETAILS	R VALUE OF INSULATION	U_f
<p>The diagram illustrates a cross-section of a floor assembly. At the top, a layer of insulation is shown with diagonal hatching. Below this is a solid line representing the sub-floor. The sub-floor is supported by a series of vertical lines representing floor joists. Below the joists, there are horizontal lines representing floor girders. Labels with leader lines point to 'INSULATION', 'SUB-FLOOR', 'FLR. JOIST', and 'FLR. GIRDER'.</p>	NO INSULATION	.32
	4	.15
	6	.12
	7	.11
	11	.08

(A)

APPENDIX B: CONTACTS AT STATE ENERGY OFFICES*

Alabama

Edwin G. Hudspeth, Staff Director
Alabama Energy Management Board
Alabama Development Office
Montgomery, Alabama 36130
(205) 832-5010

Alaska

William C. McConkey, Director
Alaska State Energy Office
Mackay Building
338 Denali Street
Anchorage, Alaska 99501
(907) 272-0527

American Samoa

Ray Costen
Special Assistant to the Governor
Government of American Samoa
Pago Pago, American Samoa 96920

Arizona

Thomas Lynch, Chief of Allocation
Fuel Allocations Section
Office of Economic Planning and
Development
Capitol Tower, Room 507
Phoenix, Arizona 85007
(602) 271-3303

Arkansas

Mac B. Woodward, Director
State Energy Office
Arkansas Department of Commerce
950 Plaza West Building
Little Rock, Arkansas 72205
(501) 371-1379

California

Bob Foster, Chief
Conservation Division
Office of Planning and Program
Development
Energy Resources Conservation
and Development Commission
1111 Howe Avenue
Sacramento, California 95825
(916) 322-4523

Colorado

Donald Crane, Director
Energy Policy Council
136 State Capitol
Denver, Colorado 80203
(303) 892-2507

Connecticut

Lynn Alan Brooks, Commissioner
Department of Planning and
Energy Policy
20 Grand Street
Hartford, Connecticut 06115
(203) 566-2800

Delaware

David Keifer, Director
State Planning Office
Delaware City, Delaware 19206
(302) 678-4271

District of Columbia

Ben Gilbert
Municipal Planning Office
Mayor's Office
Munsey Building, Room 409
1329 E Street, N.W.
Washington, D.C. 20004
(202) 629-5111

* Includes the participating 50 States and 5 territories.

Florida

Carlos Warren, Director
State Energy Office
108 Collins Building
Tallahassee, Florida 32304
(904) 488-5623

Georgia

Omi Walden, Director
State Energy Office
7 Hunter Street, S.W.
Room 145
Atlanta, Georgia 30334
(404) 656-3874

Guam

Clark Jewell, Administrator
Guam Energy Office
P.O. Box 2950
Agana, Guam 96910

Hawaii

Alfred S. Harris, Manager
Energy Management and Conservation
Office
Department of Planning and
Economic Development
Kamamalu Building
Honolulu, Hawaii 96804
(808) 548-4080

Idaho

Earl Adams, Director
Idaho Office of Energy
State House
Boise, Idaho 83720
(208) 384-3182

Illinois

~~Vacant~~, Director
Division of Energy
Department of Business and
Economic Development
222 South College Avenue -
1st Floor
Springfield, Illinois 62701
(217) 782-7500

Indiana

Thomas F. Kibler, Director
Indiana Energy Office
803 State Office Building
Indianapolis, Indiana 46204
(317) 633-6753

Iowa

Rodson L. Riggs, Director
Iowa Energy Policy Council
Valley Bank Building
707 E. Locust
Des Moines, Iowa 50317
(515) 247-4420

Kansas

Lamar Weaver, Director
State of Kansas Energy Office
503 Kansas - Room 241
Topeka, Kansas 66603
(913) 296-2496

Kentucky

Damon W. Harrison, Commissioner
Kentucky Department of Energy
Capitol Plaza Tower
Frankfort, Kentucky 40601
(502) 564-7070

Louisiana

R.T. Sutton, Assistant Secretary
Office of Conservation
Department of Natural Resources
and Energy
P.O. Box 44156
Baton Rouge, Louisiana 70804
(504) 389-5161

Maine

Abbie C. Page, Director
Office of Energy Resources
55 Capitol Street
Augusta, Maine 04330
(207) 289-2196

Maryland

John P. Hewitt, Director
Maryland Energy Policy Office
301 W. Preston Street #1302
Baltimore, Maryland 21201
(301) 383-6810

Massachusetts

Henry Lee, Director
Massachusetts Energy Policy Office
McCormack Building, Room 1413
Boston, Massachusetts 02108
(617) 727-4732

Michigan

Michael Dively, Director
Michigan Energy Administration
Michigan Department of Commerce
Law Building, 4th Floor
Lansing, Michigan 48913
(517) 374-9090

Minnesota

John Millhone, Director
Minnesota Energy Agency
740 American Center Building
160 East Kellogg Boulevard
St. Paul, Minnesota 55101
(612) 296-5120

Mississippi

George A. Cochran
Mississippi Fuel and Energy
Management Commission
P.O. Box 139
Woolfolk Senate Office Building
Room 1307
Jackson, Mississippi 39205
(601) 354-7406

Missouri

Weston Fisher, Program Director
Missouri Energy Agency
Department of Natural Resources
P.O. Box 1309
Jefferson City, Missouri 65101
(314) 751-4000

Montana

Jerry W. Toner, Staff Assistant
Montana Energy Advisory Council
c/o Lt. Governor's Office
Capitol Building 104
Helena, Montana 59601
(406) 449-2946

Nebraska

George J. Dworak, Director
Nebraska State Energy Office
P.O. Box 94841
Lincoln, Nebraska 68509
(402) 471-2867

Nevada

Noel Clark, Chairman
State Energy Resources Advisory
Board
Public Service Commission of
Nevada
505 East King Street, Capitol
Complex
Carson City, Nevada 89710
(702) 885-4180

New Hampshire

Marshall Cobleigh
Executive Vice Chairman
Governor's Council on Energy
3 Capitol Street
Concord, New Hampshire 03301
(603) 271-2711

New Jersey

✓ Burt Ross, Administrator
New Jersey State Energy Office
101 Commerce Street
Newark, New Jersey 07102
(201) 648-3290

New Mexico

John O'Leary, Director
Energy Resources Board
P.O. Box 2770
Santa Fe, New Mexico 87501
(505) 827-2146

New York

Jeffrey C. Cohen, Deputy
Commissioner
New York State Energy Office
Core One
Swan Street Building
Empire State Plaza
Albany, New York 12223
(518) 474-7927

North Carolina

Carson D. Culbreth, Chief
Conservation Branch
Energy Division, Department of
Military and Veterans Affairs
215 East Lane Street
Raleigh, North Carolina 27611
(919) 829-2230

North Dakota

T. Dwight Connor, Energy
Conservation Coordinator
North Dakota Office of Energy
Management
OPR Building - Room 270
Third and Maine
Bismarck, North Dakota 58501
(701) 224-2250

Ohio

Robert S. Ryan, Director
Ohio Energy and Resource Develop-
ment Agency
State Office Tower, 25th Floor
30 East Broad Street
Columbus, Ohio 43215
(614) 466-3465

Oklahoma

Richard G. Hill
Oklahoma Department of Energy
4400 North Lincoln Boulevard
Suite 251
Oklahoma City, Oklahoma 73105
(405) 521-3941

Oregon

Fred Miller, Director
Department of Energy
528 Cottage Street, N.E.
Salem, Oregon 97310
(503) 378-4128

Pennsylvania

William B. Harral, Executive
Director
Governor's Energy Council
Payne-Shoemaker Building, Room 905
Harrisburg, Pennsylvania 17101
(717) 787-9749

Puerto Rico

Federico Hernandez-Denton
Secretary
Department of Consumer Affairs
P.O. Box 41059, Minillas Station
Sanjurjo, Puerto Rico 00940
(809) 726-6190

Rhode Island

Victoria Potter
State Energy Coordinator
State House, Room 124
Providence, Rhode Island 02903
(401) 277-3370

South Carolina

David Harter, Director
Energy Management Office
1205 Pendleton Street
Columbia, South Carolina 29201
(803) 753-2050

South Dakota

James Van Loan, Director
Office of Energy Policy
State Capitol
Pierre, South Dakota 57501
(605) 224-3603

Tennessee

Edward J. Spitzer, Director
Tennessee Energy Office
250 Capitol Hill Building
Nashville, Tennessee 37219
(615) 741-2994

Texas

Alvin Askew
Governor's Energy Advisory Council
7703 North Lamar Boulevard
Austin, Texas 78752
(512) 475-5491

Utah

Clifford R. Collings
State Energy Coordinator
Department of Natural Resources
State Capitol, Room 438
Salt Lake City, Utah 84114
(801) 533-5356

Vermont

Forrest E. Orr
Vermont State Energy Office
State Office Building
110 State Street
Montpelier, Vermont 05602
(802) 828-2763

8/77
Brendan J. Whittaker
Executive Dept.
State of Vermont
State Energy Office
Montpelier, VT
05602

Virgin Islands

Bruce Potter
Office of Budget Director
P.O. Box 90
St. Thomas, U.S. Virgin Islands
(809) 774-0750

Virginia

Louis R. Lawson, Jr., Director
Virginia Energy Office
823 East Main Street, Room 300
Richmond, Virginia 23219
(804) 786-8451

Washington

Keith Sherman, Director
Washington State Energy Office
1000 South Cherry Street
Olympia, Washington 98540
(206) 753-2417

West Virginia

John D. Anderson, III, Director
Department of Finance and
Administration
Fuel and Energy Office
1262-1/2 Greenbrier Street
Charleston, West Virginia 25305
(304) 348-8860

Wisconsin

Stephen M. Born, Director
Office of State Planning and
Energy
1 West Wilson Street - Room B130
Madison, Wisconsin 53702
(608) 266-8234

Wyoming

Jerry Mahoney, Chief Assistant to the
Governor
State Capitol Building
Cheyenne, Wyoming 82008
(307) 777-7434

(Unofficial) 6
B

STATE DELEGATES
to the
NATIONAL CONFERENCE OF STATES ON BUILDING CODES AND STANDARDS, INC.

ALABAMA (S)

Hugh D. Adams
Director of Technical Staff
State Building Commission
State Office Building, Room 501
501 Dexter Avenue
Montgomery, Alabama 36104
(205) 832-3404

ALASKA (W)

Ronald A. Hendrie
State Fire Marshal
Department of Public Safety
Pouch N
Juneau, Alaska 99801
(907) 586-2946

ARIZONA (W)

E. R. Jones, Director
Division of Building Codes
State of Arizona
1645 West Jefferson, Room 431
Phoenix, Arizona 85007
(602) 271-4072

William T. Chaney**
Assistant Director
Division of Building Codes
State of Arizona
1645 West Jefferson
Phoenix, Arizona 85007
(602) 271-4072

ARKANSAS (S)

Ron Copeland, Director
Department of Local Services
Suite 900
First National Building
Little Rock, Arkansas 72201
(501) 371-1211

Buddy Villines**
Department of Local Services
Suite 900
First National Building
Little Rock, Arkansas 72201
(501) 371-1211

CALIFORNIA (W)

Jesse C. McElroy
Deputy Director, Department of
Housing and Community Development
921 Tenth Street
Sacramento, California 95814
(916) 445-4775

Xavier Mendoza**
Acting Chief, Codes and Standards
Department of Housing and
Community Development
921 Tenth Street
Sacramento, California 95814
(916) 445-4775

COLORADO (W)

Harold A. Knott, Director
Division of Housing
State of Colorado
1313 Sherman Street, Room 523
Denver, Colorado 80203
(303) 892-2033

CONNECTICUT (N)

Bernard E. Cabelus
State Building Inspector
Public Works Department
525 State Office Building
Hartford, Connecticut 06115
(203) 566-4036

DELAWARE (N)

J. Benjamin Roy, Jr.
State Fire Marshal
P. O. Box 109
Dover, Delaware 19901
(302) 478-4893

FLORIDA (S)

John H. Haslam, Chief
Bureau of Codes and Standards
Department of Community Affairs
2571 Executive Center Circle, East
Tallahassee, Florida 32301
(904) 488-3581

STATE DELEGATE

Page 2

GEORGIA (S)

George Bullock, Chairman
State Building Administrative Board
P.O. Box 431
Athens, Georgia 30601
(404) 543-3852

Alex C. Kelley, P.E.**
Executive Director
State Building Administrative Board
166 Pryor Street, S.W.
Atlanta, Georgia 30303
(404) 656-3930

HAWAII (W)

Howard M. Shima*, Director and
Building Superintendent
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813
(808) 523-4716

IDAHO (W)

Jack Stroud, Administrator*
Safety Inspection Division
Idaho Department of Labor and
Industrial Services
317 Main Street
Room 400, Statehouse
Boise, Idaho 83720
(208) 384-2327

ILLINOIS (M)

To be named

INDIANA (M)

Donald T. MacRae, P.E.
State Building Commissioner
300 Graphic Arts Building
215 North Senate Avenue
Indianapolis, Indiana 46204
(317) 633-5433

Ernest Eder**
State of Indiana Administrative
Building Council
300 Graphic Arts Building
215 N. Senate Avenue
Indianapolis, Indiana 46204
(317) 633-5433

IOWA (M)

Donald W. Appell
State Building Code Commissioner
State Capitol Complex
523 East Twelfth
Des Moines, Iowa 50319
(515) 281-3807

KANSAS (M)

Charles Beardmore
Division of Architectural Services
State Office Building
Topeka, Kansas 66612
(913) 296-3811

KENTUCKY (S)

Robert Estep*
State Fire Marshal
Capitol Tower Building
Frankfort, Kentucky 40601
(502) 564-3626

LOUISIANA (S)

Raymond B. Oliver
State Fire Marshal
8941 Jefferson Highway
Baton Rouge, Louisiana 70809
(504) 389-7409

MAINE (N)

Richard G. Bachelder, Director
Department of Finance and
Administration
Bureau of Public Improvements
State of Maine
Augusta, Maine 04333

MARYLAND (S)

Willard E. Bryant
Director, Codes Administration
Department of Economic & Community
Development
1748 Forest Drive
Annapolis, Maryland 21401
(301) 269-2701

MASSACHUSETTS (N)

Charles J. Dinezio
Executive Director
State Building Code Commission
John W. McCormack State Office
Building
1 Ashburton Place, Room 1305
Boston, Massachusetts 02108
(617) 727-6916

STATE DELEGATES

Page 3

1. MICHIGAN (M)

Keith Molin, Director
Michigan Department of Labor
300 East Michigan Avenue
Lansing, Michigan 48913
(517) 373-3575

Robert C. Hilprecht**
Executive Director
Bureau of Construction Codes
State Secondary Complex
7150 Harris Drive
Lansing, Michigan 48926
(517) 373-8187

MINNESOTA (M)

Norman R. Osterby, P.E.
Assistant Commissioner
Department of Administration
50 Sherburne Avenue
St. Paul, Minnesota 55155
(612) 296-7037

MISSISSIPPI (S)

Senator William J. Caraway
Executive Vice President
Mississippi Municipal Association
2301 Sun-N-Sand Building
Jackson, Mississippi 39202
(601) 353-5854

MISSOURI (M)

Douglas R. Busby
Director, Division of Mobile Homes
State of Missouri
Jefferson Building
Jefferson City, Missouri 65101
(314) 751-2557

MONTANA (W)

Delmont C. Thurber, Chairman
Montana Bldg. Codes Advisory Council
P.O. Box 6177
C. M. Russell Station
Great Falls, Montana 59406
(406) 452-0791

NEBRASKA (M)

Fred Jolly, R.S., Director
Office of Housing and Environmental
Health
Nebraska Department of Health
301 Centennial Mall South
Lincoln, Nebraska 68509
(402) 471-2541

NEVADA (W)

William E. Hancock, Manager
Nevada State Planning Board
Nye Building, Room 225
Carson City, Nevada 89701
(702) 885-4870

NEW HAMPSHIRE (N)

Roger F. Aubin*
Governor's Council on Energy
3 Capitol Street
Concord, New Hampshire 03301
(603) 271-2711

NEW JERSEY (N)

William M. Connolly, Deputy Director
Division of Housing & Urban Renewal
Bureau of Housing Inspection
363 West State Street
Trenton, New Jersey 08625
(609) 292-6415

Charles M. Decker, Chief**
Construction Code Enforcement
Department of Community Affairs
620 West State Street
Trenton, New Jersey 08625

NEW MEXICO (W)

Robert Berntsen
General Construction Board
P.O. Box 5155
Santa Fe, New Mexico 87503
(505) 827-2085

NEW YORK (N)

Bennett Selekof, Director
Housing and Building Codes Bureau
Division of Housing & Community
Renewal
Two World Trade Center
New York, New York 10047
(212) 488-7080

STATE DELEGATES

Page 4

9

NORTH CAROLINA (S)

Ern E. Church, P.E.
Deputy Commissioner
Engineering Division
Department of Insurance
P.O. Box 26387
Raleigh, North Carolina 27611
(919) 733-3901

NORTH DAKOTA (M)

Ben Meier, Secretary of State
Executive Office
Bismarck, North Dakota 58501
(701) 224-2900

OHIO (M)

Lloyd Towers, Building Commissioner
Municipal Building
High and Monument Streets
Hamilton, Ohio 45011
(513) 868-5882

OKLAHOMA (S)

Allie Isom, Director
Engineering Department
State Board of Public Affairs
State Capitol Building, Room 306
Oklahoma City, Oklahoma 73105
(405) 521-2111

OREGON (W)

Trevor Jacobson, Administrator
Building Codes Division
Department of Commerce
401 Labor & Industries Building
Salem, Oregon 97310
(503) 378-3176

David Bassett**
Assistant Administrator
Building Codes Division
Department of Commerce
401 Labor & Industries Building
Salem, Oregon 97310
(503) 378-3176

PENNSYLVANIA (N)

James W. Shields
Chief, Division of Industrialized
and Mobile Housing
State Office Building, Room 500
Harrisburg, Pennsylvania 17120
(717) 787-9682

RHODE ISLAND (N)

Joseph A. Cirillo
State Building Commissioner
12 Humbert Street
North Providence, Rhode Island 02904
(401) 277-3033

SOUTH CAROLINA (S)

Marion B. Robinson, Director
Division of Inspection Services
300 Gervais Street
Columbia, South Carolina 29201
(803) 758-2941

SOUTH DAKOTA (M)

Everett N. Quam*
State Engineer
State Office Building #2
Pierre, South Dakota 57501
(605) 224-3466

TENNESSEE (S)

Eugene Hartsook, Director
Division of Fire Prevention
202 Capitol Towers Building
Nashville, Tennessee 37219
(615) 741-2981

TEXAS (S)

Earline Jewett, Director*
Division of Housing
Department of Community Affairs
P.O. Box 13166, Capitol Station
Austin, Texas 78711
(512) 475-3383

UTAH (W)

Glen R. Swenson, Director
Utah State Building Board
124 State Capitol
Salt Lake City, Utah 84114
(801) 533-5561

VERMONT (N)

Irving A. Bates
Director of State Buildings
Agency of Administration
Montpelier, Vermont 05602
(802) 828-3314

VIRGINIA (S)

C. Sutton Mullen, Jr.
State Fire Marshal
Box 1157
Richmond, Virginia 23209
(804) 786-4751

Jack A. Proctor**
Acting State Building Codes Director
Commonwealth of Virginia
Office of Housing
6 North Sixth Street
Richmond, Virginia 23219

WASHINGTON (W)

John C. Hewitt, Director
Department of Labor and Industry
General Administration Building
Olympia, Washington 98504
(206) 753-6307

F. Byron Swigart**
Deputy Director
Department of Labor and Industry
General Administration Building
Olympia, Washington 98504
(206) 753-6307

WEST VIRGINIA (S)

Walter Smittle, III
State Fire Marshal
State Capitol, Unit 1
1800 Washington Street, East
Charleston, West Virginia 25305
(304) 348-2191

WISCONSIN (M)

John Wenning, Administrator
Safety and Building Division
Department of Industry, Labor and
Human Relations
P.O. Box 7946
Madison, Wisconsin 53707
(608) 266-1816

WYOMING (W)DISTRICT OF COLUMBIA (S)

Chief, Bureau of Building
Housing and Zoning*
Potomac Building, Room 203
614 H Street, N.W.
Washington, D.C. 20001
(202) 629-5050

PUERTO RICO (S)

Malcolm Walters-O'Neill
P.O. Box 41179
Minillas Station
Santurce, Puerto Rico 00940

VIRGIN ISLANDS (S)

Gordon A. Finch, Commissioner
Department of Public Works
P.O. Box 476
St. Thomas, U.S. Virgin Islands 00800

-
- (M) - Midwestern Region
(N) - Northeastern Region
(S) - Southern Region
(W) - Western Region
-

* Not an official delegate, only receiving mail until official delegate is appointed.
* Official state delegate alternate.

(c)

ROSTER - SUMMER INSTITUTE

State

AL Thomas F. Talbot
Director, Continuing Engineering
Education
School of Engineering
University of Alabama in
Birmingham
University Station
Birmingham, AL 35294 (205) 934-4550

AK Terry Dale
Energy and Power Development
Division
7th Floor, MacKay Building
338 Denali Street
Anchorage, AK 99501

AZ Robert D. Beeman
Planner, Energy Programs
Office of Economic Planning &
Development
Executive Tower Room 505
1700 W. Washington
Phoenix, AZ 85007 (602) 271-3303

AR Jerry Sanders
State Architect
State of Arkansas Bldg. Services
700 Medical Arts Building
12th & Marshall
Little Rock, AR 72202 (501) 371-1833

CA Wendell B. Bakken
Energy Bldgs./Appliances Spec. II
California Energy Resources Conserv.
& Development Commission
1111 Howe Avenue
Sacramento, CA 95825 (916) 322-2964

Roger L. Lorenz
Associate Civil Engineer
State of California
Dept. of Housing & Comm. Development
921 - 10th Street
Sacramento, CA 95814 (916) 445-0954

Calvin M. Jepsen
Senior Civil Engineer
State of California
Dept. of Housing & Comm. Develop.
921 10th Street
Sacramento, CA 95814 (916) 445-0954

CO

Leslie G. Tingle
Residential Const. & Insp. Engr.
Colorado Division of Housing
1313 Sherman Street
Denver, CO 80203 (303) 892-2035

Roger D. Kamp

Charles A. Smith
Bldg. & Housing Codes Inspectors
Colorado Division of Housing
1313 Sherman Street
Denver, CO 80203 (303) 892-2035

CT

Thomas D-Auria
Assistant State Building Inspector
Department of Public Works
State Office Building
Hartford, CT 06115 (202) 566-4036

DE

NOT REPRESENTED

D.C.

Ralph E. Spencer, P.E.
Acting Administrator, Bldg. &
Zoning Reg. Admin.
D.C. Dept. of Housing & Comm. Devel.
614 H Street, N.W.
Washington, DC 20001 (202) 724-8943

FL

Robert Grace
Energy Analyst
Florida State Energy Office
Room 108, Collins Building
Tallahassee, FL 32304 (904) 488-0855

GA

Walter Berry
Program Development Specialist
Institute of Government
University of Georgia
Athens, GA 30602 (404) 542-1328

Alex C. Kelley
Executive Director
State Bldg. Administrative Board
166 Pryor Street, S.W.
Atlanta, GA 30303 (404) 656-3930

GUAM

John T. Moore III
Energy Conservation Officer Engineer
Guam Energy Office
Room 402, Chase Bank Building
P.O. Box 2950
Agana, Guam 96910

HI

Francis Lau
Mechanical Engineer
Bldg. Dept., City & County of Honolulu
Honolulu Municipal Building
650 South King Street
Honolulu, Hawaii 96813 (808) 523-4505

ID

Leigh B. Lint
Bureau Chief
Idaho Dept. of Labor & Industrial
Services
317 Main Street
Room 400, Statehouse
Boise, ID 83720 (208) 384-3761

IL

Robert L. Smith
Associate Professor Architecture
University of Illinois
104 Architecture
Urbana, IL 61801 (217) 333-1330

Steven Kenneth Thomas
Technical Analyst
Division of Energy
Dept. of Business & Econ. Development
State of Illinois
222 South College
Springfield, IL 62706 (217) 782-0327

IN

Courtney E. Robinson, A.I.A.
Director of Energy Codes
State of Indiana
215 N. Senate
Indianapolis, IN 46204 (317) 633-5433

David L. Bills
Code Enforcement Supervisor
Administrative Building Council of
Indiana
215 North Senate Avenue
Indianapolis, IN 46202 (317) 633-5433

IA	<p>Delbert Wynn Building Code Engineer State of Iowa 523 East 12th Street Des Moines, IA 50319 (515) 281-3992</p>	<p>Eino Kainlauri Asst. Prof. of Architecture Iowa State University 318 Hilltop Road Ames, IA 50010 (515) 292-1645</p>
KS	<p>Louis J. Krueger Director Division of Architectural Services State of Kansas State Office Building, 12th Floor Topeka, KS 66612 (913) 296-1950</p>	
KY	<p>Earl M. Conover Educational Officer Office of State Fire Marshal Capital Plaza Tower - Third Floor Frankfort, KY 40601 (502) 564-3626</p>	
LA	<p>Louis A. deLatour Policy and Planning Engineer Dept. of Natural Resources State of Louisiana P. O. Box 44156, Capitol Station Baton Rouge, LA 70804 (504) 389-5253</p>	
ME	<p>Richard I. Nightingale Professor of Civil Engineering University of Maine 118 Boardman Hall Orono, ME 04473 (207) 581-7401</p>	<p>Richard Darling Conservation Engineer Maine Office of Energy Resources 55 Capitol Street Augusta, ME 04330 (207) 289-2196</p>
MD	<p>James R. Novak Director, Dept. of Licenses & Permits Prince George's County Service Bldg. 5012 Rhode Island Avenue Hyattsville, MD 20781 (301) 779-3850</p>	<p>Pierre H. Ossman Chief, Design & Review State of Maryland Codes Administration 1748 Forest Drive Annapolis, MD 21401 (301) 279-2701</p>

MA Frank DeFalco
Professor of Engineering
Worcester Polytechnic Institute
Civil Engineering Department
Worcester, MA 01609 (617) 753-1411

David R. Miller
Energy Coordinator
Massachusetts State Bldg. Code Commission
1 Ashburton Place
Boston, MA 02108 (617) 727-6916

Bettie-Anne C. Francis
Staff Engineer
Massachusetts Building Code Commission
One Ashburton Place, Room 1305
Boston, MA 02108 (617) 727-6916

MI Robert A. Cappelletti
Chief, Mechanical Division
Michigan Dept. of Labor
Bureau of Construction Codes
State Secondary Complex
7150 Harris Drive
P. O. Box 30015
Lansing, MI 48909 (517) 373-8754

MN William F. Wharton, P. E.
Minnesota Building Code Division
408 Metro Square Building
7th & Robert Streets
St. Paul, MN 55101 (612) 296-9992

MS Robert D. Burke
Engineer, Energy Conservation R&D
Mississippi State Bldg. Commission
1501 Walter Sillers Building
Jackson, MS 39205 (601) 354-6326

MO Jacob Thalheimer
Plan Review Engineer
St. Louis County Public Works
St. Louis, MO (312) 889-2153

MT

W. James Kembel
Chief, Building Codes Admin. Bureau
State of Montana
Capitol Station
Helena, MT 59601 (406) 449-3933

George T. Nolan, Jr.
Engineer
A/E Division, State of Montana
State Capitol
Helena, MT 59601 (406) 449-3104

NE

Jack Daniel
Asst' Director, Div. of Housing &
Environmental Health
Nebraska State Dept. of Health
301 Centennial Mall South
Lincoln, NE 68509 (402) 471-2541

NV

Elliott W. Gritton
Mechanical Engineer
Nevada State Public Works Board
Room 400, Kinkead Bldg.
505 E. King Street
Carson City, NV 89710 (702) 885-4870

NH

Roger F. Aubin
Director of Conservation
Governor's Council on Energy
3 Capitol Street
Concord, NH 03301 (603) 271-2711

Howard Raymond
Code Administrator
Code Administration Department
City Hall
Concord, NH 03301 (603) 224-2397

NJ

Charles M. Decker
Chief, Construction Code Enforcement
N. J. State Dept. of Community Affairs
Box 418 Mountaintop
Glen Gardner, NJ 08826 (609) 292-6364

Elliot B. Reiff
Principal Engineer, Construction Code
Enforcement
N. J. State Dept. of Community Affairs
Dept. of Community Affairs
363 W. State Street
Trenton, NJ 08625 (609) 292-6364

NM James O. Dritt
Senior Research Associate
New Mexico Energy Institute/
The University of New Mexico
117 Richmond, N. E.
Albuquerque, NM 87106 (505) 277-3661

Richard W. Lisle
Chief Administrator, Mechanical Board
State of New Mexico Construction Indus.
Comm.
1131 Siler Road
P. O. Drawer 5155
Santa Fe, NM 87503 (505) 827-2085

Tom Shishman
117 Richmond Drive, N. E.
Albuquerque, NM 87106 (505) 277-3661

Robert H. Berntsen
Chief Administrator, General Construction
Board
State of New Mexico Construction Indus.
Comm.
1131 Siler Road
P. O. Drawer 5155
Santa Fe, NM 87501 (505) 827-2085

NY Bennett Selekof, P. E.
Assistant Director, Building Code Bureau
New York State Division of Housing
Two World Trade Center
New York, NY 10047 (212) 488-7080

NC Robert Wray
Head, Energy Division
Department of Insurance
P. O. Box 26387
Raleigh, NC 27611 (919) 733-3901

James Quinn
Energy Conservation Architect
Department of Insurance
P. O. Box 26387
Raleigh, NC 27611 (919) 733-3901

ND Robert W. Lawyer
State Construction Superintendent
State of North Dakota
Office of the Secretary of State
Bismarck, ND 58501 (701) 224-2905

John S. Hegedus
Director of Inspection
City of Bismarck
North Dakota Assoc. of Bldg. Inspectors
Box 1578
Bismarck, ND 58501 (701) 223-5597

OH Gerald Bruce
Chief, Division Factories & Buildings
Department of Industrial Relations
2323 West Fifth Avenue
Columbus, OH 43204 (614) 466-6631

OK Dean D. Scott
Plans Review Inspector
City of Tulsa, Protective Inspections
Room 424, City Hall, 200 Civic Center
Tulsa, OK 74103 (918) 581-5321

OR Walter M. Friday
Chief Structural Code Engineer
State of Oregon Bldg. Codes Division
Room 401 Labor & Industries Bldg.
Salem, OR 97310 (503) 378-8086

Jerry Hoard
Supervisor Prefab. Structures Unit
State of Oregon Bldg. Codes Division
Room 401, Labor & Industries Bldg.
Salem, OR 97310 (503) 378-8319

PA Randall Lee Pickett
Energy Conservation Specialist
Governor's Energy Council
State Street Building, Sixth Floor
Harrisburg, PA 17101 (717) 783-8186

RI Dr. Lewis Conta
Director, Energy Center
Department of Mechanical Engineering
University of Rhode Island
Kingston, RI 02881 (401) 792-2192

SC Mac V. Vinh
Assistant Building Official
City of Columbia
P. O. Box 147
Columbia, SC 29217 (803) 765-1041 X 236

SD Bruce R. Kraft
Technical Analyst
South Dakota Office of Energy Policy
Foss Building - Room 402
Pierre, SD 57501 (605) 224-3603

TN Eugene W. Edmunds
Staff Engineer
Tennessee Energy Office
Room 250, Capitol Hill Building
Nashville, TN 37219 (615) 741-2994

TX Thomas D. Wright
Business & Industrial Prog. Manager
Governor's Energy Advisory Council
7703 North Lamar
Austin, TX 78752 (512) 475-7017

UT Dr. Arthur L. Jones
Energy Conservation Engineer
Utah State Building Board
124 State Capitol
Salt Lake City, UT 84114 (801) 533-5561

R. F. Barrett
Energy Conservation Engineer
South Carolina Energy Management Office
1205 Pendleton Street
Columbia, SC 29201 (803) 758-2050

John D. Johnson
Codes Specialist
Tennessee Housing Development Agency
500 United American Bank Building
Nashville, TN 37219 (615) 741-2400

Vernon E. Beringer
Codes Specialist, Finance & Devel. Section
Texas Dept. of Community Affairs
Housing Division
P. O. Box 13166, Capitol Station
Austin, TX 78712 (512) 475-3383

Sanford Baum
Mechanical Engineering Department
University of Utah
Salt Lake City, UT 84112 (801) 581-7565

VT John Couture
Electrical Engineer
Couture Engineering Company
86 Hadley Street
S. Burlington, VT 05401 (802) 862-0904

V.I. Harry O. Parrott
Director, Projects, Design & Engineering
Department of Public Works
P. O. Box 476
St. Thomas, V.I. 00801 (809) 774-2515

VA Jack A. Proctor
State Building Code Director
Office of Housing
Six North Sixth Street, Suite 202
Richmond, VA 23219 (804) 786-7891

John W. Spears
Building Code Supervisor
Virginia Office of Housing
Six North Sixth Street
Richmond, VA 23219 (804) 786-7891

WA NOT REPRESENTED

WV John Herholdt, Jr.
Assistant Director
West Virginia Fuel & Energy Office
1262½ Greenbrier Street
Charleston, WV 25311 (304) 348-8860

WI Ergun I. Somersan
Director (Chief Engineer)
Dept. of Industry Labor & Human Rel.
201 E. Washington Avenue
Madison, WI 53702 (608) 266-1817

Ronald Lewis Buchholz
Architect, Admin. Code Consultant
State of Wisconsin
Dept. of Industry, Labor & Human Rel.
201 E. Washington Avenue
Madison, WI 53702 (608) 266-1903

Charles Fafard
Head, Energy Section
State of Wisconsin
Dept. of Industry, Labor & Human Rel.
Division of Safety and Buildings
201 E. Washington Avenue
Madison, WI 53702 (608) 266-2151

WY Billy M. Weckwerth
Wyoming State Fire Marshal
State of Wyoming Dept. of Fire Prevention
720 West 18th Street
Cheyenne, WY 82002 (307) 777-7288

Paul Christensen
Plans Examiner
State of Wyoming Dept. of Fire Prevention
720 West 18th Street
Cheyenne, WY 82002 (307) 777-7288