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10 CFR Part 435

Energy Efficiency Code For New Federal Residential Buildings; Proposed Rule

DEPARTMENT OF ENERGY

Office of Energy Efficiency and Renewable Energy

10 CFR Part 435

[Docket No. EE–RM–96–300]

RIN 1904–AA53

Energy Efficiency Code for New Federal Residential Buildings

AGENCY: Office of Energy Efficiency and Renewable Energy, DOE.

ACTION: Notice of proposed rulemaking, public hearing, and request for public comment.

SUMMARY: The Department of Energy today proposes a rule that would establish minimum energy-efficiency building standards for new Federal residential buildings, including single-family and multi-family low-rise housing, pursuant to the requirements of the Energy Conservation and Production Act of 1976, as amended. The proposed rule would cover all aspects of residential building thermal envelopes, including foundations, crawl spaces, floors, walls, fenestration, roof/ceilings, and attics. The proposed rule would also cover the heating, ventilation, and air-conditioning systems design, service water heating systems, radon control, air infiltration, and electrical power and lighting systems. The proposed rule would revise the current Federal residential standards to conform generally with the format and language of the Council of American Building Officials Model Energy Code, 1992. The proposed rule is, on the average, 11 percent more energy-efficient than the Model Energy Code, 1992 for single-family residences and 26 percent more energy-efficient than the Model Energy Code, 1992 for multi-family residences for heating and cooling.

DATES: Written comments on the proposed rule (ten copies and, if possible, a computer disk containing the electronic file of these comments) must be received on or before July 14, 1997. A public hearing will be held in Washington, D.C., on June 5, 1997, beginning at 9:30 a.m. at the address listed below. Requests to speak must be received by the Department on or before June 3, 1997. Ten copies of the statement to be given at the public hearing must be received by the Department by 4:00 p.m., June 3, 1997.

ADDRESSES: Written comments on the proposed rule (ten copies), as well as requests to speak at the public hearing, requests for copies of the technical support documents and requests for speaker lists should be addressed to: U.S. Department of Energy, Energy Efficiency Code for Federal Residential Buildings, Docket Number EE-RM–96–300, Office of Codes and Standards, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, Room 1J–018, 1000 Independence Avenue, S.W., Washington, D.C. 20585–0121, (202) 586–7574.

Fax comments will not be accepted. The public hearing will be held at the U.S. Department of Energy, Forrestal Building, Room 1E–245, 1000 Independence Avenue, S.W., Washington D.C. 20585–0121. Copies of the transcripts of the public hearings and written public comments received may be read at the Department of Energy's Freedom of Information Reading Room, U.S. Department of Energy, Forrestal Building, Room 1E–190, 1000 Independence Avenue, S.W., Washington, D.C. 20585–0121, (202) 586–6020, between the hours of 9:00 a.m. and 4:00 p.m., Monday through Friday, except Federal holidays. The reference standards are also available from the sources listed in Subpart H of the proposed rule. For more information concerning public participation see section IX. Public Comment Procedures.

FOR FURTHER INFORMATION CONTACT:

Stephen P. Walder, Office of Codes and Standards, EE–43, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Room 1J–018, 1000 Independence Avenue, S.W., Washington, D.C. 20585–0121, (202) 586–9209;

Francine B. Pinto, Esq., Office of General Counsel, GC–72, U.S. Department of Energy, Room 6E–042, 1000 Independence Avenue, S.W., Washington, D.C. 20585–0103, (202) 586–7432.

SUPPLEMENTARY INFORMATION:

I. Introduction

A. Authority

The Department today proposes a rule that would establish Federal building energy-efficiency standards for new Federal residential buildings pursuant to section 305(a) of the Energy Conservation and Production Act (ECPA), as amended by the Energy Policy Act of 1992 (EPACT), 42 U.S.C. 6834(a). In developing this proposed rule, the Department is directed to consult with other Federal agencies as well as private and state associations and other appropriate persons.

Section 305(a)(1) of the ECPA requires the Department to establish Federal building energy standards that include those energy-efficiency measures that are technologically feasible and economically justified. The standards must contain energy saving and renewable energy specifications that meet or exceed the energy saving and renewable energy specifications of the Council of American Building Officials (CABO) Model Energy Code (MEC), 1992. Section 305(a)(2)(A).

Section 305(a)(2)(B) requires that to the extent practicable, the proposed standards use the same format as the appropriate voluntary building energy code, in this case, the MEC, 1992. Furthermore, Section 305(a)(2)(C) requires that the proposed rule be established in consultation with the Environmental Protection Agency (EPA) and other Federal agencies and, where appropriate, contain measures with regard to radon and other indoor air pollutants.

The current energy performance standards for new Federal buildings remain in effect until the standards established under subsection (a) become effective. Section 305(d). These current standards are found in 10 CFR Part 435, Subpart C.

Section 306 addresses Federal compliance. Each Federal agency and the Architect of the Capitol must adopt procedures to assure that new Federal buildings will meet or exceed the Federal building energy standards proposed here. Section 306(a). Section 306(b) bars the head of a Federal agency from expending Federal funds for the construction of a new Federal building unless the building meets or exceeds the appropriate Federal building energy standards established under Section 305.

B. Background

There are currently three building energy codes that address low-rise residential buildings in all parts of the United States [1]: the Model Energy Code (MEC); 10 CFR Part 435, Subpart C, *Mandatory Performance Standards for New Federal Residential Buildings*; and the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), Inc., Standard 90.2–1993, *Energy-Efficient Design of New Low-Rise Residential Buildings*. All three bear on today's proposed rule. The MEC contributes format, substance, and technical improvements to the proposal. The Federal residential standards first introduced the concept of cost-effectiveness in building standards and tools to analyze the economic justification of energy-efficiency requirements in building standards. Tools that evolved from the development of the current Federal residential standards were used to determine the economic justification for the requirements contained in the proposed rule. ASHRAE Standard 90.2–1993 also provides substantive technical improvements to the proposal.

1. Model Energy Code, 1992

Currently, the MEC is the most widely accepted and used residential energy-efficiency code in the United States. Seventeen states have adopted the MEC, or modified versions of the MEC, as their energy code. Approximately 20 percent of new home loans are issued or guaranteed by the Department of Housing and Urban Development, the Department of Veterans Affairs, and the Rural Economic and Community Development group of the Department of Agriculture. Such loans or loan guarantees require compliance with the MEC, 1992. The MEC has been promulgated jointly by the three model code organizations: the Building Officials and Code Administrators International; the International Conference of Building Officials; and the Southern Building Code Congress International under the auspices of the Council of American Building Officials. The MEC is provided as a model and intended for adoption by state and local jurisdictions.

The provisions of the MEC, 1992 regulate the design of building envelopes for adequate thermal resistance and low air leakage and the design and selection of mechanical, electrical, service water-heating and illumination systems and equipment which will enable effective use of energy in new building construction. The MEC provides flexibility to permit the use of innovative approaches and techniques to achieve efficient utilization of energy. These provisions are structured to permit compliance with the intent of the code by any one of the following paths of design: (1) A systems analysis approach for the entire residential building and its energy-using subsystems, including buildings which utilize renewable sources (Chapter 4), (2) a building design by component performance approach (Chapter 5) and, (3) building design by acceptable practice (Chapter 6).

2. The Current Federal Standards

On August 25, 1988, the Department published standards for new Federal residential buildings (53 FR 32536). It established building energy-efficiency standards for the design and construction of Federal residential buildings.

The current Federal standards require that Federal agencies use software to create project-specific compliance forms that are then completed by prospective builders to demonstrate compliance with minimum energy-efficiency requirements. The process must be undertaken for each project. The micro-computer software program, *Conservation Optimization Standard for Savings in Federal Residences* (COSTSAFR), uses local construction, maintenance and replacement costs, local climate data, and local fuel costs to determine an energy-efficient and cost-effective energy usage goal for any of nine residential building unit types addressed in the COSTSAFR program data base. COSTSAFR calculates project-specific minimum energy-efficiency requirements and presents these requirements in compliance forms known as ''the point system.'' The use of COSTSAFR eliminated the need for performing lengthy calculations or making uninformed choices regarding the selection of energy-efficiency measures. COSTSAFR is designed so that implementing officials, designers, and builders can easily tell if a proposed combination of measures will result in energy-efficiency levels that meet or

[1] There are other building energy codes that are state-specific or regional that are not considered.

exceed the COSTSAFR required level for cost-effective energy-efficiency in a building.

The Department decided not to use COSTSAFR as the basis for this new Federal proposed rule because it cannot always be assured of complying with the new legislative requirements. In particular, COSTSAFR can generate energy-efficiency requirements that do not meet the MEC, 1992 energy-efficient levels specified by EPACT. The software would have to be reconfigured to eliminate this possibility.

3. Standard 90.2–1993

Standard 90.2–1993, *Energy-Efficient Design of New Low-Rise Residential Buildings,* is a standard for residential construction published by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), Inc. Standard 90.2–1993 is the next generation residential component of ASHRAE's earlier Standard 90 (1975) and Standard 90A–1980, which specified design requirements for energy-efficient commercial and residential buildings. Standard 90.2–1993 sets criteria for the building envelope, heating equipment and systems, air-conditioning and systems, and provisions for overall building design alternatives and trade-offs.

II. Relationship Between the Proposed Rule, the MEC, 1992, the Current Federal Residential Standards, Standard 90.2–1993, and Other Federal Initiatives

A. General

The Department has decided to develop a proposed rule similar in format to the MEC rather than modify the current Federal residential building standards. Currently, construction professionals are more familiar with the MEC, 1992 format and content than the Federal standards. This familiarity with the MEC requirements and format is likely to reduce costs associated with the development and use of building specifications consistent with those of the MEC. The consistency of the proposed rule with industry-wide practice will facilitate implementation by Federal agencies of the final rule. Currently, 10 CFR Part 435 contains standards for Federal commercial buildings (Subpart A), a reserved section that was intended for voluntary standards for new non-Federal residential buildings (Subpart B), and standards for Federal residential buildings (Subpart C). On August 6, 1996, the Department proposed to remove Subpart A from Part 435 and republish it as a new Part 434 in the Code of Federal Regulations. (61 FR 40882). In today's proposed rule, Subparts B and C would be removed and Part 435 would be revised to establish standards for Federal residential buildings only.

B. Relationship Between the Proposed Rule and the MEC, 1992

The proposed rule would adopt portions of the Model Energy Code, 1992 verbatim. There are, however, some requirements in the proposed rule that exceed the MEC, 1992 resulting in increased energy-efficiency. Many of the provisions improving energy-efficiency are found in the 1993 and 1995 versions or the 1994 amendments to the MEC, 1993. Those aspects of the proposed rule that exceed the MEC, 1992 resulting in increased energy-efficiency are: (1) more stringent thermal envelope requirements, (2) insulating of crawl space walls, (3) sealing recessed light fixtures, (4) heating and cooling equipment capacity requirements, (5) air distribution system construction, and (6) heat traps.

The proposed rule would also make revisions to the Model Energy Code, 1992, that are consistent with current building construction practice. These include requirements for: (1) insulation inspection, (2) window and door thermal performance ratings, (3) improved performance path specifications, (4) metal framing construction and, (5) radon and other indoor air pollutants. The requirements referenced in (1)–(4) above, do not save energy but help ensure that energy savings are achieved. Requirements concerning radon and other indoor air pollutants are consistent with health and safety needs.

Further, the Department has made miscellaneous minor changes to the MEC, 1992 to improve the clarity and useability of the rule. These miscellaneous changes are not expected to have any impact on the agencies or their contractors.

The proposed rule is on the average, 11 percent more energy-efficient than the Model Energy Code, 1992 for single-family residences and 26 percent more energy-efficient than the Model Energy Code, 1992 for multi-family residences for heating and cooling.

C. Relationship Between the Proposed Rule and the Current Federal Residential Standards

There are significant differences and similarities between the proposed rule and the current standards. The current standards have a point system related to energy cost that permits tradeoffs among energy-efficiency measures, while the proposed rule has an overall U-value that permits tradeoffs in envelope measures. The use of microcomputer software is necessary to determine the requirements of the current standards, whereas, the requirements of the proposed rule are contained in a hardcopy publication. Both have a similar whole building energy usage analysis compliance approach.

The current Federal standards will not always assure the user of meeting or exceeding the requirements of the MEC, 1992. The Department has demonstrated that residential buildings designed using COSTSAFR will have a less stringent level of thermal performance than those buildings designed using the requirements of the proposed rule.

D. Relationship Between the Proposed Rule and Standard 90.2–1993

A number of features from Standard 90.2–1993 are included in today's proposed rule. These provisions address feasible residential design features not presently or adequately addressed by the MEC, while providing the potential for further energy savings in the proposed rule. They include heating and cooling equipment sizing limitations; default thermal performance data for metal frame walls; and heat traps on water heaters for potable water.

Standard 90.2–1993 has been put into code format providing a similar structure for both the standard and the proposed rule. Both also have three alternative compliance paths of similar nature. Standard 90.2–1993 however, has more complexity than the respective compliance options of the proposed rule. The Department believes that this greater complexity of Standard 90.2–1993 would make it more difficult to adopt, use, and enforce than the MEC, which is the basis for the proposed rule. The Department also believes that the complexity and differences between Standard 90.2–1993 and the MEC would have made it difficult for the Department to have assured the user of meeting the minimum energy-efficiency requirements of the MEC, 1992. The Department determined that the necessary cost and resources to revise Standard 90.2–1993 as the proposed Federal residential rule and that would meet or exceed the MEC, 1992 would not be warranted. The proposed rule looks to the broad recognition and penetration enjoyed by the MEC within the community of residential designers, builders and enforcement officials to facilitate its implementation by the Federal sector.

E. Relationship to Other Federal Initiatives

The proposed rule would establish the minimum level of energy-efficiency for new Federal buildings. The rule works in conjunction with two related Federal initiatives designed to encourage cost-effective efficiency improvements for new buildings beyond the minimum requirements of the proposed rule. First, *Executive Order on Energy Efficiency and Water Conservation at Federal Facilities,* Executive Order No. 12902 (59 FR 11463, March 8, 1994), specifically requires that, ''Each agency involved in the construction of a new facility—shall: (1) design and construct such facility to minimize the life cycle cost of the facility by utilizing energy efficiency, water conservation, or solar or other renewable energy technologies.'' Section 306(a) of Executive Order 12902. It also requires agencies to ''ensure that the design and construction of facilities meet or exceed the energy performance standards applicable to Federal residential or commercial buildings as set forth in 10 CFR Part 435, local building standards, or a Btu-per-gross square-foot ceiling—whichever will result in a lower life cycle cost over the life of the facility.'' Section 306(a)(2) of Executive Order 12902. In addition, Federal agencies shall increase, to the extent practicable and cost-effective, purchases of products that are in the upper 25 percent of energy efficiency for all similar products, or products that are at least 10 percent more efficient than the minimum level that meets Federal standards. Section 507(a)(2) of Executive Order 12902. This latter provision is being implemented through the Department's ''Procurement Challenge Program'' that notifies Federal agencies of the availability and performance of these high-efficiency options. This ''Procurement Challenge Program'' is being coordinated with the EPA ''Energy Star'' product specification activities. In addition, the Department's Office of Building Technologies, State and Community Programs provides detailed technical information on state-of-the-art energy-efficiency equipment for new buildings. These sources of technical assistance can help Federal agencies specify highly-efficient equipment for new Federal residential buildings.

Second, section 435.108 of today's proposed rule references the requirements of 10 CFR Part 436 governing life-cycle cost analysis for Federal energy investments. The life-cycle cost analysis provisions found in 10 CFR Part 436 allow agencies to determine when additional or alternate energy-efficiency measures would provide net benefits in the form of energy cost savings to ensure that measures selected are cost-effective to the Federal government. This is especially relevant in areas where energy costs are higher than presumed for the analysis supporting today's proposal, and for innovative technologies and specifications that cannot be readily incorporated into the proposed rule. The microcomputer program entitled ''ARES'' (Automated Residential Energy Standard) can be used for evaluating the life-cycle cost-effectiveness of various thermal envelope energy-efficiency measures (EEMs) that can be more energy-efficient than the requirements of the proposed rule. The Department is currently conducting life-cycle cost analysis that would identify energy-efficiency measures that are economically justified in specified circumstances and exceed the minimum requirements of the proposed rule. The Department will provide the results of this analysis to the Federal agencies to assist them in the design and construction of energy-efficient Federal residential buildings.

III. Description of the Proposed Rule and Differences Between the Proposed Rule and the Model Energy Code, 1992

This section describes the proposed rule and the differences between the proposed rule and the Model Energy Code, 1992. Those sections of the proposed rule not specifically addressed here have been adopted from the MEC, 1992. Minor language and citation changes will not be noted. The discussion below corresponds to the subparts, sections, paragraphs, and subparagraphs in the proposed rule. The sections identified as reserved are discussed briefly.

A. Subpart A: Administration and Enforcement

This subpart describes the scope and general requirements of the rule, the requirements concerning the identification and maintenance information on building materials and equipment, the use of alternate materials, the application of the proposed rule if sections are in conflict, and the requirement for a life-cycle cost analysis.

Proposed sections 435.101–108 contain changes from the MEC, 1992, as discussed below. The Department believes that the provisions discussed below are technologically feasible, and are of such minimal cost that the benefits of such requirements make them economically justified.

1. Sections 435.102.1.2 and 435.102.1.3: Building Envelope Insulation and Insulation Installation

The sections require that insulation installed in the building be clearly marked so that the ''R-value'' of the insulation can be easily verified. The blown or sprayed attic insulation ''depth'' marker requirement is contained in the MEC, 1995 but not in the MEC, 1992. The insulation depth markers will help ensure that the claimed thickness of the loose-fill ceiling insulation can be verified. Verification of the ceiling insulation assures that the designed energy-efficiency performance of the building ceiling can be achieved at a minimal cost to the government. The associated costs are minimal compared to the possibility of installing insulation that is less than the required designed thickness and thereby loses energy. The use of depth markers is technologically feasible because a marker is a simple ruler graduated in one-inch increments and affixed to the roof/ceiling framing.

2. Section 435.102.3: Fenestration Product Rating, Certification, and Labeling

Section 121 of EPACT requires the Secretary of Energy to make a determination, within one year of enactment, on whether a window energy rating and labeling program established by the National Fenestration Rating Council (NFRC) meets the objectives of the legislation. If not, the Department is to develop a mandatory rating program. The Secretary's provisional determination concluded that the NFRC voluntary national window rating program meets the requirements of EPACT. (September 23, 1994, 59 FR 48865, 48868). The Department supports the NFRC efforts to establish a uniform, national rating, certification and labeling program through incorporation of the NFRC program in Federal, state and local government and national voluntary codes and standards.

The verification of window and door assembly U-values is a significant element in determining the overall U-value or thermal performance of the building envelope, which is a key factor in achieving compliance with the proposed rule. Section 435.102.3 of the proposed rule requires that when Federal agencies purchase fenestration products, the U-value (conductive heat transfer) for that fenestration product (window, door, and skylight) shall be assigned. If the product has been tested in accordance with NFRC 100–91 (Procedure for Determining Fenestration

Product Thermal Properties), the NFRC U-value shall be used. The rating procedure tests the fenestration products to determine the conductive heat transfer properties and/or characteristics of the product.

If fenestration products are not tested in accordance with NFRC 100–91, a default U-value will be assigned, using Tables 102.3.1 and 102.3.2 located in the Appendix of the proposed rule. The default values represent a conservative energy-efficiency performance potential of a product based on characteristics of the product which are verifiable by visual inspection. The NFRC 100–91 rating procedure and the default U-value tables for non-tested products in the proposed rule are those found in the MEC, 1995.

There is no standard for rating the energy-efficiency (U-values) of window and door assemblies in the MEC, 1992. The inclusion of the requirement to assign U-values to fenestration products will potentially save energy costs by eliminating inaccurate U-values or ratings that do not reflect the total window or door assembly thermal performance. Thus assigning U-values or default U-values helps to ensure that the claimed thermal performance of fenestration products will actually be achieved in housing construction.

The NFRC procedure provides a fair and accurate rating of window and door thermal performance. Over 22,000 products have been rated by the NFRC. The ratings of window and door thermal performance are recognized by at least six states in their building code provisions regarding energy-efficiency.

Windows and doors that are rated in accordance with NFRC 100–91 may result in an expenditure by the product manufacturer. However, NFRC 100–91 is set up so that every window or door unit need not be tested individually. The results of a few actual tests are extrapolated by computer modeling to the manufacturer's entire product line. Thus the per unit cost of receiving a NFRC rating is relatively small. Alternatively, a fenestration product manufacturer can elect not to test and save the associated costs, and receive the default U-value rating.

Assigning a U-value according to the new rating procedure can change the rating received by particular windows. A model that was previously rated at 0.4 might, for example, be rated under the new system at 0.5. As a result, there may be situations in which agencies would change the window selected in order to keep with the code's U-value requirements. That change could result in higher purchase prices, but would reduce building energy use as well. The use of energy-efficient windows is becoming standard building construction practice in most regions of the nation, particularly in the northern tier states, indicating their general cost-effectiveness in today's building markets. Given the nominal cost per unit for NFRC testing and rating and the general cost-effectiveness of energy-efficient windows, the Department has determined that the assigning of U-values in accordance with NFRC 100–91 or default U-values in the proposed rule is economically justified. See the Technical Support Document, section 6.7, page 6.6.

3. Section 435.104: [Reserved]

The proposed rule does not include the section entitled, ''Plans and Specifications'' from the MEC, 1992.

4. Section 435.105: [Reserved]

The MEC, 1992 has requirements concerning the inspection by the building official of construction or work for which a building permit is required. Federal agencies have various procedures concerning the inspection of construction. Section 435.105 is reserved in the proposed rule to allow Federal agencies the flexibility of using their own requirements concerning the inspection of residential construction.

5. Section 435.106: [Reserved]

The proposed rule does not include the section entitled, ''Validity'' from the MEC, 1992.

6. Section 435.107: Precedence

The Model Energy Code, 1992 contains no statement addressing the order of precedence between potentially conflicting requirements of the proposed code and those of a reference standard. Section 435.107.1 of the proposed rule clarifies which requirements that shall apply.

7. Section 435.108: Life-Cycle Cost Analysis

The MEC, 1992 contains no requirements related to life-cycle costs. The proposed rule would require building design(s) of Federal residential buildings to be evaluated consistent with Subpart A of 10 CFR Part 436, which specifies methodologies and procedures for life-cycle cost analyses of Federal buildings.

B. Subpart B: Definitions

This subpart includes definitions for all relevant words or phrases that have a specific meaning within the context of the rule. In accordance with the proposed rule, new definitions not in the MEC, 1992 have been added and unneeded definitions have been removed. For example, definitions related to the radon control requirements have been added and definitions related to non-residential HVAC systems and components not regulated by this rule have been deleted. Appendix D in the Technical Support Document identifies those definitions that have been added or removed.

C. Subpart C: Design Conditions

This subpart gives sources for heating and cooling degree-day data, establishes design conditions for the sizing of the heating, ventilating, and air-conditioning system, and provides reference standards for mechanical ventilation criteria. Other than identifying cooling degree-days and providing more specific information on where one may obtain weather data, this section is unchanged from the MEC, 1992.

D. Subpart D: Design by Systems Analysis; Design Utilizing Renewable Energy Sources

This subpart contains a compliance approach that may be used as an alternative to Subpart E. Subpart E contains the minimum energy-efficiency requirements for the thermal performance of new Federal residential buildings.

Subpart D requires that the user conduct an annual energy analysis. It defines the general methodology and rules for this energy comparison. A proposed building complies with this rule if its calculated annual energy usage is less than or equal to the energy usage of a similar building (referred to as the ''standard design'') designed in accordance with Subpart E. The annual energy analysis methodology is equivalent to that in Chapter 4 of MEC, 1992 but provides more direction and specific detail on how the annual energy analysis shall be conducted, as discussed below.

1. Section 435.402.1: Energy Analysis

A critical parameter for performing any comparative energy analysis is defining the space heating, air conditioning, and service water heating equipment and the efficiency or performance levels of that equipment for the ''standard'' design.

As in the MEC, 1992, the proposed rule would require that the standard and the proposed design be compared utilizing the ''same energy source(s) for the same functions.'' These energy sources are determined by the Subpart E provisions governing the selection of equipment. This energy consumption provision is similar to the provision in section 402.1 contained in the MEC, 1992 and 1993. The only substantive difference between the proposed rule and the earlier versions of the MEC that relate to this section is the application of life-cycle cost requirements.

In order to comply with Subpart D, a proposed design must be at least as life-cycle cost-effective as the standard design and use no more energy than the standard design. In the event that the proposed design utilizes more than one energy source and increases the consumption of one energy source and decreases the consumption of the other energy source, then the overall energy consumption, measured at the site, must be less than or equal to the standard design. Because the energy sources in the standard and proposed design must be the same, changes in energy consumption that affect more than one energy source would be limited to variations in equipment efficiency and types and building thermal envelope efficiencies.

Because methods for consistently measuring and comparing the energy performance of new technologies take time to develop, the proposed design may utilize newer equipment types not covered using current Department test procedures. The Department is requesting comment on methods of addressing newer equipment technologies for which a recognized means of evaluating and comparing energy performance have not yet been fully developed.

2. Section 435.402.1.1: Input Values/Assumptions for Group R (Single-Family and Multi-family Low Rise) Buildings

This proposed rule specifies input values/assumptions for certain energy-related building parameters that must be used in the whole building energy analysis comparison. These values were taken from the MEC, 1995. In contrast, the MEC, 1992 does not provide specification of these values. For example, if the builder or designer chooses to use the annual energy analysis approach, the thermostat set points that must be assumed are given in Table 402.1.1–4, whereas the MEC, 1992 provides no information.

The specification of input values/assumptions performs two functions. First, it eliminates the time and effort that each user needs to set these values/assumptions individually. Second, it establishes ground rules that ensure consistency among different whole building annual energy analyses and helps prevent misuse of this approach.

The Department has determined that specifying the input values/assumptions to annual energy analyses comparisons is technologically feasible because it is consistent with current building energy usage analysis practice and is the only way to verify consistency in analytical results across the different analytical tools. The specification of input values is also economically justified since failure to specify such input values could result in the approval of noncomplying or unrealistic building designs and unnecessary energy cost increases. The introduction of erroneous data would add unwarranted time, effort, and cost to the project.

The Department has included many new annual energy analysis input values/assumptions in the proposed rule. *See* the Technical Support Document, section 6.8, page 6.8.

3. Section 435.403.3: Passive Solar Design Analysis

The MEC, 1992 and 1995 do not include direction on methodologies for measuring the energy impacts of solar space conditioning. This section of the proposed rule allows for the optional use of ''BuilderGuide,'' a software program that calculates heating and cooling loads for solar technologies. ''BuilderGuide'' was produced by the Department in partnership with the Passive Solar Industries Council and the National Renewable Energy Laboratory. The resulting ''BuilderGuide'' package is specific to some 2400 United States locations, and uses a methodology that is based on 15 years of solar energy research. The Department has determined that ''BuilderGuide'' is a well developed, widely distributed and recognized software program. Other reliable tools for calculating energy usage of solar technologies or other new energy-efficiency measures can be used. The Department recognizes that designs using renewable energy sources for space conditioning or water heating may be economically justified. The Department is promoting ways to further stimulate the use of renewable sources of energy. The Department welcomes additional suggestions on approaches for crediting measures that use renewable sources of energy.

E. Subpart E: Design by Component Performance Approach

Sections 435.501–505 contain the minimum energy-efficiency requirements for the thermal performance of building envelope components, building mechanical systems and equipment, service water heating, and electrical power and lighting. Compliance with the requirements of Subpart E is required unless the optional compliance approach prescribed in Subpart D is used.

The building envelope requirements apply to the building components enclosing conditioned space, including: roof/ceilings, above grade walls, slab-on-grade floors, floors over unconditioned spaces, basement walls, crawl space walls, doors, windows, and skylights. The proposed rule also contains requirements limiting air infiltration through the building envelope.

The mechanical systems and equipment performance requirements set heating and cooling equipment load capacity (sizing) limits, temperature and humidity control requirements, distribution system construction and insulation requirements, and backdrafting testing requirements. The requirements relating to electrical power and lighting systems apply only to multi-family residences. The mechanical equipment section does not require mechanical equipment efficiencies that exceed current Federal minimum standards.

Sections 435.501–505 of the proposed rule in Subpart E revise and update the requirements contained in Chapter 5 of the MEC, 1992. Subpart E contains two separate building envelope compliance approaches. The two approaches are: (1) The individual component performance approach and, (2) the whole building performance approach. The individual component performance approach (section 435.502.2.1) gives maximum U_0[2] requirements for the floor over unheated spaces, wall, and roof/ceiling. The different elements of the wall (insulation, windows, doors, opaque wall), the floor (insulation, type of floor), or the roof/ceiling (insulation, skylights, type of ceiling) may be varied to achieve the U_0. The whole building performance approach (section 435.502.2.2) defines the maximum U_0 requirement for the entire building. The user can then tradeoff among the requirements for the walls, floors, and roof/ceilings as long as the maximum U_0 for the entire building is not exceeded.

1. Major Revisions From the Model Energy Code, 1992 That Are Contained in Subpart E of the Proposed Rule

The major substantive changes from the MEC, 1992 as found in Subpart E are described below.

a. Section 435.502: Building thermal envelope requirements. The tables

[2] U_0 = the area-weighted average thermal transmittance of an area of the building envelope; i.e., the exterior wall assembly including fenestration and doors, the roof and ceiling assembly, and the floor assembly (British thermal unit/(hour x square feet x degrees Fahrenheit).

found in proposed section 435.502, and Figures 1 through 6 in the Appendix contain the building thermal envelope requirements. These requirements are significantly changed from the MEC, 1992 and generally are more stringent than the MEC, 1992, except for the requirements for crawl space walls which are essentially the same as those in the MEC, 1992. The requirements that are more stringent than the MEC, 1992 consist of maximum U_0-values for above-grade walls including windows and doors, roof/ceilings, floors over unheated spaces, basement walls, and minimum R-values for slab-on-grade perimeters. When describing the thermal performance of a building component, consider that the lower a U_0-value, the more energy-efficient the component and the higher a R-value, the more energy-efficient the component.

The Department conducted a life-cycle cost economic analysis, as specified at 10 CFR Part 436, to analyze these thermal envelope requirements so as to minimize life-cycle costs to the Federal government. The assessment was conducted using the ARES computer software analyzing information such as the average Federal cost of energy, expected energy price increases, and typical costs for installation and maintenance of proposed measures. The economic analysis considered construction-related costs and space heating and cooling energy costs for 881 cities and eight types of common heating fuel/equipment types. *See* the Technical Support Document (chapters 2 thru 5) for a detailed description of the analysis to establish the building thermal envelope requirements.

b. Section 435.502.2.1.1.2: Metal framing. The proposed rule includes a detailed new table (Appendix Table 502.2.1.1.2) to provide users with the correction factors for the thermal-performance values of wall assemblies framed with metal studs. Table 502.2.1.1.2 does not appear in the MEC, 1992 but is in the MEC, 1995 and Standard 90.2–1993. This table provides a standardized treatment of heat loss through walls framed with metal studs. The thermal performance requirements of such walls are the same as those for wood-framed walls. Metal framing is technologically feasible. Metal wall assemblies have become more popular over the last several years due in part to the price increase of wood. Metal framing is not required by the rule and need not be specified where not cost-effective or otherwise not preferred.

c. Section 435.502.2.1.5: Crawl space walls. Section 435.502.2.1.5 of the proposed rule requires floors above crawl spaces vented to outdoors to be insulated. This requirement is contained in the MEC, 1995, but is not in the MEC, 1992. In the MEC, 1992 insulating the crawl space wall was not dependent on whether the crawl space was ventilated. Wall insulation for vented crawl spaces is ineffective because outside air will enter the crawl space through the vents. Increased energy usage results from the uninsulated heat transfer path through the floor above. Crawl space wall insulation in the proposed rule is an option only if the crawl space is not vented. The Department has determined that the insulation of floors over vented crawl spaces is technologically feasible since it is part of current standard building construction practice.

Further, the requirement is economically justified. *See* the Technical Support Document, section 6.3, page 6.2.

d. Section 435.502.3.3: Recessed lighting fixtures. Recessed lighting fixtures, when installed in the building envelope, must be properly sealed to prevent unwanted ceiling air leakage. The requirement is contained in the MEC, 1995. Without this requirement, recessed lighting fixtures can be a significant source of energy loss due to air leakage into the attic space. The MEC, 1992 has no requirements relating specifically to recessed lighting fixtures.

The Department has determined that the insulation and sealing of recessed lighting fixtures are technologically feasible. These practices are used in current building construction practice. The requirement is economically justified because the incremental cost for installing well-sealed recessed light fixtures is less than the cost of the energy that would otherwise be lost over the 25-year analysis period. *See* the Technical Support Document, section 6.6, page 6.5.

e. Section 435.503.2: Mechanical equipment efficiency. Section 435.503.2 addresses the selection of heating and cooling equipment with attention to the use of life-cycle cost principles. The primary difference between the MEC, 1992 and the proposed rule regarding this section is that the proposed rule includes provisions addressing the life-cycle cost of the installed equipment. The MEC, 1992 has no requirements concerning life-cycle cost principles. In the proposed rule when selecting among equipment options that are minimally compliant with Federal performance standards, that option with the lowest life-cycle cost is to be selected. The proposed rule allows for the selection of equipment that exceeds Federal minimum efficiency standards under Subpart E providing the equipment is at least as life-cycle cost effective as equipment that is minimally compliant with Federal standards. Agencies are encouraged through the Procurement Challenge program and other Federal initiatives to consider more energy-efficient equipment.

Given the large range of heating and cooling equipment types and efficiencies available, this section provides a simplified method for incorporating life-cycle cost principles into equipment selection. Two options are provided for: the first option requires Federal agencies to select the most cost-effective equipment that is minimally compliant with Federal standards. For central heating and cooling equipment systems for multi family dwellings that service multiple rather than individual dwelling units, minimum equipment efficiencies found in the codified version of ASHRAE Standard 90.1–1989 are used. This approach is consistent with the overall rule, which sets building envelope efficiency requirements at a level that is cost-effective on average when equipment at minimum Federal efficiency levels is used. The second option allows for the use of any other equipment available, provided that it is at least as cost-effective as the heating and cooling equipment identified under the first option. This second option allows for the use of more efficient versions of equipment that are subject to minimum Federal standards and would allow use of equipment, such as natural gas heat pumps or ground source heat pumps, that are not covered by the Federal standards.

It is anticipated that for most buildings, an informal comparison of local costs and fuel availability will identify a few systems as the most likely to be the most cost-effective; these systems can then be compared in more detail to identify the system that has the lowest life-cycle cost under the first option. If any other equipment is preferred, a single additional calculation will establish whether it is more cost-effective than the system identified in the first option.

f. Section 435.503.3.1.1: Heating and cooling equipment capacity. The Department has included limits on equipment capacities in section 435.503.3.1.1 of the proposed rule. These requirements are taken from the codified version of Standard 90.2–1993. The MEC, 1992 has no requirements relating to the sizing of heating and cooling equipment. Oversizing of heating and cooling equipment results in increased energy usage since the equipment cycles on and off more frequently and, therefore, runs at a lower average efficiency than properly sized equipment. Furthermore, oversized cooling equipment is less able to remove moisture from the air and, therefore, is less able to control humidity. Also, oversized heating, ventilating, and air-conditioning equipment also generally costs more to purchase than properly sized equipment. The Department believes that the requirement is technologically feasible and economically justified based on the discussion above. *See* the Technical Support Document, section 6.2, page 6.2. However, in very well insulated homes, equipment sizing could be such that the smallest available size of intended equipment might not meet the proposed sizing requirement. The Department would appreciate comments on what designers should do if unable to obtain equipment within the equipment capacity requirements.

g. Section 435.503.5.7.2: Duct sealing. The proposed rule would contain duct sealing requirements that are more stringent than those in the MEC, 1992. A requirement that all low-pressure air ducts be sealed with mastic with fibrous backing tape was added as section 435.503.5.7.2 of the proposed rule. This requirement is also in the MEC, 1995.

Leaking supply and return ducts decrease heating and cooling equipment efficiency and increase energy usage while not meeting resident comfort requirements. Many studies of actual houses have revealed leaky ducts to be a major source of energy loss. One study showed leaks of 15 percent can reduce air conditioner efficiency by 33—50 percent. *See* the Technical Support Document, section 6.4, page 6.4. To address these problems, the proposed rule requires all low-pressure supply and return ducts outside the conditioned space to be sealed with mastic with fibrous backing tape. In contrast, the MEC, 1992 requires only that the supply ducts are sealed and allows any type of tape.

Current construction practice allows the use of duct tape to ''seal'' cracks and crevices in supply and return air ducts. Duct tape however, is not a sealant. A clean surface and a tight fit are required to produce a ''seal'' at installation and neither of these conditions is routinely met. If a ''seal'' is obtained at installation, however, the tape degrades over time as a result of deterioration of the glue. Properly installed duct tape ''seals'' often will leak within a year or two. Repairing leaking ducts after construction can be costly or impractical because ducts are often in inaccessible locations or they are wrapped with insulation that must be removed and replaced.

Mastic is a permanent sealant. It does not degrade over time, and is expected to last for the life of the home. Installation is uncomplicated, with several methods of application from which to choose. Mastic has excellent adhesive and cohesive properties, even on typically dirty or oily surfaces found at the construction site. The cost of sealing ducts in existing housing is estimated to range from $50 to $300 when the installer has unrestricted access to the ducts without making it necessary to remove the finished material that may cover the ducts. The cost will clearly be lower during construction in new housing. This requirement is technologically feasible because mastic and tape sealing are found in current building construction practice. The requirement is economically justified because the cost of the energy saved over the 25-year analysis period would exceed the cost of the additional labor and materials that would be used to comply with this section. *See* the Technical Support Document, section 6.4, page 6.4.

h. Section 435.503.5.9.1: Backdrafting test. The Department has included requirements relating to the prevention of backdrafting of fossil-fuel-burning appliances in the proposed rule. The MEC, 1992 has no requirements relating to this potential health hazard. Chimney backdrafting in fossil-fuel-burning appliances such as oil or gas-fired water heaters, gas-fired clothes driers, fireplaces, or wood stoves is a potential threat to occupant health in residential buildings. Chimney backdrafting can occur when exhaust gases are drawn into a building through the chimney or vent because air pressure is lower inside the building than outside. Chimney backdrafting can cause serious health problems and even death can occur from exhaust gases containing or leading to the formation of carbon monoxide. Infants are particularly at risk because their respiratory systems are not fully developed, and they are susceptible to health effects at lower concentrations than are safe for most healthy adults. Sulfur dioxide and carbon dioxide also circulates in occupant breathing spaces as a result of backdrafting. These gases can cause long-term health effects such as chronic respiratory illness, or short-term health effects such as discomfort, shortness of breath, and respiratory irritation.

The Department has determined that tests for potential backdraft problems should be performed in all homes with fossil-fuel-burning appliances that do not obtain exhaust combustion air directly from the outside. These tests shall be performed because the potential for chimney or venting failure exists in all homes and especially in all well sealed, poorly ventilated homes with combustion equipment. Tight building envelopes can cause stack-effect-induced depressurization and powered exhaust fans can exacerbate the problem.

The test specified in the proposed rule is taken from the Canadian spillage test developed by the Canadian General Standards Board. The test measures the inside/outside pressure differential across a building shell with a micromanometer under best-case and worst-case scenarios. The test then compares the measurements to depressurization limits for combustion appliances in the house. When depressurization measurements exceed limits, remedial action is required before the house can pass the spillage test and comply with the rule. The Department has reviewed the Canadian spillage test and determined that it is technologically feasible and has included it in the proposed rule. *See* Technical Support Document, section 8.0, page 8.1.

The cost to perform a backdrafting test is estimated to be between $50 and $100, depending on factors such as: the complexity of the house, the number of houses in a given area to be tested, and local weather conditions. This cost range does not include remedial measures. The Department has determined that there is a potential risk of backdrafting which justifies the inclusion of this requirement which is consistent with health and safety needs. *See* the Technical Support Document, section 8.0 for more information. The Department requests the public to comment on whether carbon monoxide alarms should be required in Federal residences.

i. Section 435.504.2: Service water heating equipment. Section 435.504.2 addresses the selection of service water heating equipment with the application of life-cycle cost requirements. As with space heating and cooling equipment, Federal agencies may either (1) select the most cost-effective domestic water heating equipment that minimally complies with Federal standards or (2) select any other equipment that is at least as life-cycle cost-effective. More efficient equipment may be selected under Subpart E. Agencies are encouraged through the Procurement Challenge program and other Federal initiatives to consider more energy-efficient equipment.

j. Section 435.504.4: Heat traps. Heat traps are one-way valves or pipe configurations that prevent thermal diffusion or thermal siphoning of potable water from the hot water heater in the house through the water distribution system, thus needlessly dissipating heat. Section 435.504.4 of the proposed rule requires that water heaters with vertical pipe risers have heat traps. This requirement is not in the MEC, 1992 and was taken from the codified version of Standard 90.2–1993. Heat traps are also technologically feasible because they are part of current water heater manufacturing practice. The use of heat traps is a low-cost method of reducing water heating energy use already installed on many commercially available water heaters. Therefore, heat traps are economically justified because the net annual savings over the lifetime of the water heater exceeds the initial first cost of the additional hardware. *See* the Technical Support Document, section 6.5, page 6.5.

2. Miscellaneous Revisions That Are Contained in Subpart E of the Proposed Rule, Not in the MEC, 1992

The proposed rule includes the following additional requirements that are not part of the MEC, 1992. Section 435.502.1.4 contains a clarification to the MEC, 1992 in that access openings, which are considered part of the thermal envelope element, must be evaluated as part of the overall building thermal envelope element (e.g., floors, walls, roof/ceiling, etc.,). The Department believes this is technologically feasible because access openings are commonly insulated in colder climates and are economically justified because it imposes no additional cost to the building. *See* the Technical Support Document, section 6.9, page 6.10.

Section 435.502.1.5 contains a requirement for the insulation of foundations supporting masonry veneer. The Department has determined that the requirement is technologically feasible because it reflects current building construction practice. Although some energy would be lost, the energy loss would be small and economically justified when weighed against the costs that would be incurred by damage to the masonry veneer. Damage can occur due to settling of the masonry as the insulation is compressed. The technical justification for this requirement may be found in the Technical Support Document, section 6.10, page 6.10.

Section 435.502.2.1.3 contains an equation to calculate the total floor heat loss of the proposed building. The equation requires that all floors of different construction (in aggregate) must meet the U_0 requirements for floors over unheated spaces. The Department has determined that the requirement is technologically feasible. The technical justification for this requirement may be found in the Technical Support Document, section 6.11, page 6.10. The equation is economically justified because the use of the equation to determine the U-value requirement for floors over unheated spaces is cost-effective. Variations in floor configurations are not required by this proposed rule.

Section 435.502.2.1.4 contains a clarification of acceptable slab insulation placement which reflects current building construction practice. The Department has determined that the requirement is technologically feasible because it reflects current standard building construction practice. The technical justification for this requirement may be found in the Technical Support Document, section 6.11, page 6.11. The clarification is economically justified because it imposes no additional slab insulation requirements. There is a potential for installation cost savings due to the flexibility offered by the proposed requirement.

Section 435.502.3.2 simplifies language on caulking and sealing requirements for typical air sealing measures. The Department has determined that the requirement is technologically feasible because the simplified language generally reflects the requirements contained in the MEC, 1992. The technical justification for this requirement may be found in the Technical Support Document, section 6.13, page 6.12. The simplified language is economically justified because it imposes no additional costs to the construction of the building.

Section 435.502.3.1 refers to updated reference standards for allowable infiltration rates for windows and doors. This section reflects current manufacturing standards for air-tightness of pre-fabricated windows and doors. The Department has determined that the requirement is technologically feasible because current manufactured windows and doors are built to the updated referenced standards. The updated reference standards are economically justified because the proposed rule imposes no additional cost or requirements on manufacturing quality or performance. The technical justification for this requirement may be found in the Technical Support Document, section 6.15, page 6.14.

F. Subpart F: [Reserved]

Subpart F is reserved for a simplified compliance approach the Department is developing. This approach will make it easier to determine compliance with this rule. This revised simplified compliance approach would be different from that contained in the MEC, 1992, 1993, and 1995. This approach is expected to be similar to the Department's ''MECcheck'' tables which display pre-calculated configurations in compliance with the MEC, 1992, 1993 or 1995. The Department is planning to produce a ''Federal'' version of MECcheck.

G. Subpart G: Radon Control

Subpart G provides the minimum requirements for the control of radon from the ground and from construction materials associated with Federal residential buildings. The application of requirements for radon control apply in addition to the provisions of Subpart D or E.

The ECPA, as amended, directs that the Federal residential building energy standard ''consider, in consultation with the Environmental Protection Agency and other Federal agencies, and where appropriate contain, measures with regard to radon and other indoor air pollutants.'' 42 U.S.C. 6834(a)(2)(C). The intent is for the Department to address health concerns related to air quality in Federal buildings.

The Department has determined that radon is a potential health hazard in residential buildings and that the proposed rule should address radon testing and mitigation requirements. Radon is a gas that exists naturally in many soils and enters a building through the foundation. Radon concentrations in soil vary widely across the United States and even within a small region, such as a county. If high concentrations of radon are present in the soil below a building, then measures to control radon are needed. Approximately 6 percent of existing single-family homes in the United States or 5.8 million homes in 1990 have average radon levels greater than 4 pCi/L per year, the threshold level determined by the EPA to require corrective action. Approximately 0.7 percent of existing single-family homes in the country have average radon levels greater than 10 pCi/L per year. The EPA estimates that indoor radon causes between 7,000 and 30,000 lung cancer deaths per year. This range is based on the uncertainty inherent in the many factors contributing to the risk of radon exposure and on a national residential radon survey estimate of an average level of 1.25 pCi/L per year. The EPA's best estimate is that 14,000 lung cancer deaths per year result from residential radon exposure.

In this proposed rule the Department would be accepting EPA's determination that radon-resistance control measures should only be required in zones (counties) of high radon potential. Such zones are defined by the EPA ''U.S. Map of Radon Zones'' or local data if available. The proposed rule specifies the EPA ''U.S. Map of Radon Zones'' as the default source designating counties where the proposed requirements apply. Table 702.2 in the Appendix of the proposed rule lists the applicable counties. The EPA ''U.S. Map of Radon Zones'' is not always sufficient to predict radon concentrations accurately. There may be instances where specific locations will be assigned to an inappropriate radon potential zone in the EPA ''U.S. Map of Radon Zones''. To accommodate for such inaccuracies, the proposed rule allows considering appropriate evidence and ''overruling'' the EPA ''U.S. Map of Radon Zones.''

Consideration of non-EPA data is justifiable given that studies on radon concentrations in many Federal installations are already available or are underway.

The proposed rule uses the following approach for addressing radon when radon-resistant construction is necessary:

(1) Foundation sealing with passive (non-mechanical) venting of soil gas to the outside;

(2) Long-term and short-term post-occupancy radon testing to verify occupant safety;

(3) Mitigation, if the tests reveal high radon concentrations; and

(4) Post-mitigation testing for radon and potential backdrafting to ensure safety.

Each of these four approaches is described in further detail below. The proposed radon requirements are technologically feasible because the techniques used are part of current standard building construction practice in many areas of the U.S. and are consistent with the EPA *Model Standards and Techniques for Control of Radon in New Residential Buildings* (EPA 402–R–94–009, March 1994). The Department is accepting EPA's analysis of the costs and benefits of radon control. See RS–34, pages ES–1–ES–4. The Technical Support Document (Chapter 7.0) provides construction specifications and technical justifications for the proposed rule. The proper initial abatement approach in areas of potentially high radon concentrations is to seal potential sources of air leakage in the foundation and vent the soil gas below the foundation. Such venting uses a pipe that extends from the foundation, through the house, and out the roof. This approach is consistent with the approach in the EPA *Radon Mitigation Standards* (EPA 402–R–93–078, October 1993). It cannot be conclusively determined before construction that a radon source exists that is strong enough to raise indoor concentrations above the EPA action level. Therefore, it would be fiscally imprudent initially to require measures beyond foundation sealing and the ''passive'' vent pipe. If elevated radon levels are found after construction and these initial measures were not installed, the cost of the retrofit would be much higher than the cost during initial construction.

The radon concentration within a residence can only be determined after the residence is built and occupied. This is due to the interaction of radon sources with construction characteristics of the house and the indoor pressure-driven air flow that is influenced by heating, ventilating and air-conditioning equipment under occupant control. Because short-term tests are not adequate to obtain annual average radon concentrations, the proposed rule requires long-term post-occupancy testing of residences built in specified locations. The long-term test requires between 6 months and 1 year and is the most accurate measure of chronic radon levels an occupant will encounter. A short-term test which lasts between seven and 60 days, is also proposed to ensure that occupants are not exposed to radon levels in excess of 20 pCi/L while the long-term test is in progress. Testing procedures and devices must conform to the EPA *Protocols for Radon and Radon Decay Measurements in Homes* (EPA 402–R–93–003, June 1993).

Testing may show that sealing the foundation and installing the passive vent are not sufficient to control the radon level. In such cases, the proposed rule requires that a fan be installed and operated in the foundation vent system to lower radon concentrations. Vent fans must be activated when the long-term test reveals radon concentrations greater than the EPA action level of 4 pCi/L or if the first short-term test and a second short-term confirmatory test reveals radon levels in excess of 20 pCi/L. The EPA *Radon Mitigation Standards* offer guidance on installing the fan.

Follow-up tests are required to ensure that the vent fan is successful at lowering indoor radon levels. Additionally, because the foundation vent fan may under certain circumstances cause fossil-fuel-burning appliances to tend to backdraft, both the proposed rule and the EPA *Radon Mitigation Standards* require testing for backdrafting of chimney and combustion vents. Section 435.503.5.9.1 of the proposed rule, referenced in Subpart G, specifies the test procedure to be used to check for potential backdrafting.

The Department departs from the EPA ''Radon Mitigation Standards'' in several respects. First, the proposed rule allows data on radon concentrations at Federal facilities to take precedence over the EPA ''U.S. Map of Radon Zones'' for determining whether radon-resistant construction is required. Second, if the housing is located in a high radon zone, the proposed rule requires testing and, if necessary, mitigation and further post mitigation testing. Third, many sections of the EPA *Radon Mitigation Standards* that are unenforceable, including discussions, explanations, or recommendations, have been deleted. Fourth, the Department provides more detail in some construction specifications so that the required measures can be more easily verified. Fifth, the Department did not explicitly include the EPA requirements for sealing the above-grade structure to help limit air infiltration through the foundation. This was because similar requirements are already included in section 435.502.3 of the proposed rule.

The Department has thus followed the general approach outlined in the EPA *Radon Mitigation Standards.* Radon-resistant construction is only required in locations with high radon potential and a phased approach to control is specified. Control should be based on a sealed foundation, passive venting of soil gas and radon testing after occupancy. Only if necessary should a fan be added to the vent system. The Department consulted and provided to the EPA draft copies of the proposed rule (including radon requirements) and the Environmental Assessment supporting the proposed rule. The EPA has provided extensive comments on the requirements for radon in the proposed rule and the Department has incorporated many of those comments in Subpart G.

H. Subpart H: Standards

This section provides a list of all the standards referenced in the proposed rule. This section has been updated from the MEC, 1992 because some requirements contained in this proposed rule are not contained in the MEC, 1992 reference standards. Also, some referenced standards have been updated to newer versions since 1992.

IV. Consultation

In developing today's proposal, the Department has consulted with outside parties, including state and local code officials, private sector representatives, and other Federal agencies, as required by section 305(a)(1) of ECPA.

In addition, the Department continues to work with the relevant private sector organizations and the states to analyze potential improvements to the MEC and to facilitate the adoption of such improvements in both the public and private sectors. Adoption of the MEC format in today's proposal provides a ready basis for the incorporation of future code improvements as they are developed and approved through the standard process for model code change proposals.

Finally, the Department will specifically provide Federal agencies with information regarding the availability of energy-efficiency equipment and emerging developments that improve building envelopes. This support will help keep Federal agencies current regarding energy-efficiency opportunities between the updates of this rule.

V. Energy and Economic Impacts

Section 305(a)(2)(A) of ECPA requires that the proposed rule meet or exceed the MEC, 1992. The proposed rule is based on the MEC, 1992, with the additions described in Section III above. Overall, the proposed rule, if adopted would reduce energy use by approximately 11 percent for single-family residences and 26 percent for multi-family residences, as compared to the MEC, 1992.

The energy estimates reported here are based on the minimum specifications required in Subpart E of the proposed rule. Additional cost-effective energy-efficiency improvements in new Federal residential buildings are facilitated by this rule through Subpart D, which provides a means of documenting the energy savings and cost-effectiveness of more energy-efficient building designs.

The Department has prepared a Technical Support Document that includes an economic analysis. It concludes that there are no significant adverse economic effects from adopting the proposed rule. The proposed rule, when compared to the MEC, 1992, will result in a positive net flow of benefits from energy savings that more than offsets higher capital construction and other costs at estimated Federal costs of energy.

The national net effect of the proposed rule is a cumulative savings of $870,000 for the approximately 3,000 Federal housing units constructed each year. These net effects are based on the net present value of energy savings and capital costs over a 25-year period. *See* the Economic Analysis at page 6.

VI. Technological Feasibility and Economic Justification

The standards proposed today are technologically feasible and economically justified to the Federal government as required by Section 305(a)(1) of ECPA.

The Department used the life-cycle cost methodology reflected in the microcomputer program entitled ''ARES'' for evaluating the life-cycle cost-effectiveness of various thermal envelope EEMs. Only those EEMs the Department judged technologically feasible were reviewed.

The life-cycle cost analysis compares the cost and benefits of all the EEMs. The HVAC equipment performance efficiencies are specified at current minimum EPCA levels. *See* 10 CFR Part 430. These are the same levels found in the MEC, 1993. Given a set of fuel prices, financial and economic parameters, and EEM costs for a specific location, ARES identifies the life-cycle cost resulting from any given set of EEMs. Energy costs and discount rates reflect estimated Federal costs of energy and the Federal discount rate established annually by the Federal Energy Management Program for the life-cycle cost analysis required by 10 CFR Part 436. The present value of the total costs for several EEMs are compared, and the results are used to set the code to energy-efficiency measure levels that achieve the lowest energy-related total cost for construction, operation and maintenance for each location studied. The resulting thermal-envelope-component values are presented as a function of heating degree-days.

The technical feasibility of the EEMs contained in the ARES energy data base was assessed by determining that they were technologically verifiable, commercially available, and in common construction practice. Construction features that cannot be analyzed by ARES because the technical or economic data has not been well established, or features that have small additional costs but significant potential for energy savings, have been analyzed by practicable architectural, engineering, or economic judgment.

VII. Measures Concerning Radon and Other Indoor Air Pollutants

Section 305(a)(2)(C) of the ECPA requires the Department to consider, where appropriate, measures with regard to radon and other indoor air pollutants. The Department has proposed a set of radon requirements concerning the control and mitigation of radon in Federal residences. These requirements draw heavily from the EPA *Radon Mitigation Standards,* EPA 402-R–93–078, April 1994. As part of these proposed requirements, post-occupancy testing is proposed for locations with high radon potential to discover whether radon concentrations within the residences are acceptable. The proposed Federal rule also includes requirements for addressing the potential for backdrafting of combustion by-products, such as carbon monoxide, from fossil-fuel-burning appliances.

VIII. Findings and Certification

A. Review Under the National Environmental Policy Act

The Department has completed an Environmental Assessment (EA), see *Environmental Assessment of the Impacts on Building Habitability and the Outdoor Environment Resulting from the Proposed Federal Residential Code,* in support of the proposed rule, pursuant to the implementing regulations of the Council on Environmental Quality (CEQ) (40 CFR Parts 1500–1508), the ''National Environmental Policy Act of 1969, as amended,'' (NEPA) (40 U.S.C. 4221 *et seq.*), the Department's NEPA Implementing Procedures, (10 CFR Part 1021), and the Secretarial Policy on the National Environmental Policy Act (June 1994). Section V.B.2. of the Secretarial Policy requires, wherever possible, that the Department provide an opportunity for interested parties to review environmental assessments prior to the Department's formal approval of such assessments. The written public comment procedures for this EA are discussed below in section IX.

The draft EA addresses the possible incremental environmental and indoor habitability effects attributable to the application of the proposed rule. The analysis in the draft EA demonstrates that the potential environmental effects from the proposed rule would be limited. The only impacts would be a decrease in outdoor air pollutants resulting from decreased fossil fuel burning and temporary increases in formaldehyde concentrations in the Federal residences.

B. Environmental Protection Agency Review

As required by the Federal Energy Administration Act of 1974, 15 U.S.C. 766(a)(1), a copy of this proposed rule was submitted to the Administrator of the Environmental Protection Agency for comments on the impact of the proposed rule on the quality of the environment.

C. Regulatory Planning and Review

This regulatory action has been determined to be a significant regulatory action under Executive Order No. 12866, 58 FR 51735 (October 4, 1993), but not economically significant. Accordingly, today's action was subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) and OIRA has completed its review.

D. Federalism Review

Executive Order 12612, 52 FR 41685 (October 30, 1987), requires that regulations, rules, legislation, and any other policy actions be reviewed for any substantial direct effects on states, on the relationship between the Federal government and the states, or in the distribution of power and responsibilities among various levels of government. If there are substantial effects, then the Executive Order requires preparation of a federalism assessment to be used in all decisions involved in promulgating and implementing a policy action.

The proposed rule would establish energy-efficiency requirements solely applicable to new Federal residential buildings. It does not impose any requirements on state governments. Therefore, the Department finds that today's proposed rule, if finalized, will not have a substantial direct effect on state governments, therefore, a federalism assessment has not been prepared.

E. Review Under the Executive Order on Metric Usage in Federal Government Programs

Section 5164(b) of the Omnibus Trade and Competitiveness Act of 1988, 15 U.S.C. 205b, which amended the Metric Conversion Act of 1975, designates the metric system of measurement as the preferred system of weights and measures for trade and commerce. This law requires Federal agencies by the end of fiscal year 1992 and to the extent economically feasible, to use the metric system in U. S. procurements, grants, and other business-related activities, except to the extent that such use is impractical or likely to cause significant inefficiences or loss of markets to U.S. firms. The Omnibus Trade and Competitiveness Act of 1988 also requires Federal agencies to establish guidelines and to report as part of its annual budget submission on the actions it plans in order to implement fully the metric system of measurement. This policy is also stated and amplified by Executive Order 12770 of July 25, 1991, ''Metric Usage in Federal Government Programs.''

This rule is the first use of a dual metric/English (soft metric conversion) system of measurement in a Federal building energy regulation. The metric system of measurement is followed by the English system in parentheses. In using this dual system, the Department is facilitating the goal of 15 U.S.C. 205b to promote competitiveness by relating Federal energy standards to the international measurements that United States companies must use to meet world demand for building components. The rule retains reference to English system measurements for those companies that do not have the ability to readily translate between metric and English units. The use of this dual system of measurement does not change the requirements of the proposed rule and has no substantive impact on the users of the proposed rule.

F. Review Under Executive Order on Civil Justice Reform

Section 3 of Executive Order 12988, 61 FR 4729 (February 7, 1996), instructs each agency to adhere to certain requirements in promulgating new regulations. These requirements, set forth in Section 3(a) and (b), include eliminating drafting errors and needless ambiguity, drafting the regulations to minimize litigation, providing clear and certain legal standards for affected legal conduct, and promoting simplification and burden reduction. Agencies are also instructed to make every reasonable effort to ensure that the regulation describes any administrative proceeding to be available prior to the judicial review and any provisions for the exhaustion of administrative remedies. The Department has determined that today's regulatory action meets the requirements of section 3(a) and (b) of Executive Order 12988.

G. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980, 5 U.S.C. 601–612, requires that an agency prepare an initial regulatory flexibility analysis and that it be published at the time of publication of general notice of proposed rulemaking for the rule. This requirement does not apply if the agency ''certifies that the rule will not, if promulgated, have a significant economic impact on a substantial number of small entities.'' 5 U.S.C. 605.

The proposed rule only imposes requirements on the Federal government for the construction of new Federal residential buildings. Therefore, the Department certifies that this rule, if promulgated, would not have a significant economic impact on a substantial number of small entities.

H. Paperwork Reduction Act Review

This proposed rule was examined with respect to the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.*, which directs agencies to minimize Federal information collection and reporting burdens imposed on individuals, small businesses, and state and local governments.

This proposed rule would establish requirements for the design of new Federal residential buildings. It does not impose requirements for the collection or reporting of information to the Federal Government. Accordingly, clearance under the Paperwork Reduction Act of 1980 is not required by the Office of Information and Regulatory Affairs of the Office of Management and Budget.

I. Review Under Section 32 of the Federal Energy Administration Authorization Act

Pursuant to Section 301 of the Department of Energy Organization Act (Pub. L. 95–91), the Department is required to comply with Section 32 of the Federal Energy Administration Authorization Act of 1974, as amended by section 9 of the Federal Energy Administration Authorization Act of 1977. The findings required of the Department by Section 32 serve to notify the public regarding the use of commercial standards in a proposal and through the rulemaking process. It allows interested persons to make known their views regarding the appropriateness of the use of any particular commercial standard in a notice of proposed rulemaking. Section 32 also requires that the Department consult with the Attorney General and the Chairman of the Federal Trade Commission concerning the impacts of such standards on competition.

Today's proposed rule adopts, in significant part, the MEC, 1992, 1993 and 1995 and the relevant reference standards (RS) contained in the MEC, 1992, 1993, and 1995. The reference standards can be found in Subpart H of the proposed rule designated as RS–1—RS–34. In addition, the proposed rule adopts certain requirements from Standard 90.2–1993.

The Department has evaluated the promulgation of the above standards with regard to compliance with Section

32(b). The Department is unable to conclude whether these standards fully comply with the requirements of Section 32(b), i.e., that they were developed in a manner which fully provided for public participation, comment, and review. Therefore, the Department now invites public comment on the appropriateness of incorporating these industry standards in its final rule. As required by Section 32(c), the Department will consult with the Attorney General and the Chairman of the Federal Trade Commission concerning the impact of these standards on competition, prior to issuing a notice of Final rulemaking.

J. Unfunded Mandates Reform Act Review

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Pub. L. 104–4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by state, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. The requirements do not apply if the rule incorporates regulatory requirements that are specifically set forth in law. 2 U.S.C. 1531, 1532.

Furthermore, section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of state, local, and tribal governments on a proposed ''significant intergovernmental mandate.'' A ''significant intergovernmental mandate'' under the Act is any provision in a Federal agency regulation that: (1) would impose an enforceable duty upon state, local, or tribal governments (except as a condition of Federal assistance); and (2) may result in the expenditure by state, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals. 2 U.S.C. 1533.

The rule proposed today would establish building energy-efficiency standards for new Federal residential buildings pursuant to section 305(a) of the Energy Conservation and Production Act, as amended. 42 U.S.C. 6834(a). It does not include any Federal requirements that would result in the expenditure of money by state, local, and tribal governments. Therefore, the requirements of the Unfunded Mandates Reform Act of 1995 do not apply to this rulemaking.

IX. Public Comment Procedures

A. Participation in Rulemaking

The Department encourages the maximum level of public participation in this rulemaking. Representatives of Federal agencies, utilities, state and local governments, building code organizations, and builder associations, building owner associations, as well as individuals, architects, engineers, builders, building owners, consumers, and others are urged to submit written statements on the proposed rule. The Department also encourages interested persons to participate in the public hearing to be held in Washington, D.C., at the time and place indicated in this Notice.

The Department of Energy has established a comment period of 90 days following publication for interested persons to comment on this proposed rule. All comments will be available for review in the Department's Freedom of Information Reading Room.

B. Solicitation of Public Comments

The Department welcomes comments on any aspects of the proposed rule and supporting documentation, including the draft EA. In particular, the Department is seeking comments on those specific issues described below. The Department requests that comments of a technical nature be supported by substantive data.

In particular, the Department requests comments addressing the quantitative and methodological basis for setting specific ventilation requirements in energy codes that relate to Federal residential construction. Ventilation can help mitigate indoor air pollutants and moisture problems in many situations. Excessive ventilation, however, can increase energy use but not necessarily mitigate the health effects of some indoor air pollutants. The Department is interested in comments on how best to set ventilation requirements to achieve adequate indoor air quality without incurring unnecessary construction or energy costs.

Second, the Department seeks comments on whether all residences with fuel-burning devices requiring a vent pipe or chimney should be required to undergo testing for depressurization-induced chimney failure (backdrafting). The Department has included this requirement in the proposed rule because of the health hazard of backdrafting.

Third, the Department specifically requests comments regarding the treatment of equipment efficiency for space heating and cooling and water heating. The proposed rule incorporates the existing Federal minimum appliance standards, while relying on other Federal initiatives to encourage the identification and use of more efficient equipment where economically justified.

The Department would have to establish the economic benefits and technological feasibility of any equipment efficiency specifications that would be included in this rule that exceed the Federal minimum requirements.

Fourth, the Department requests comments concerning the technological feasibility and economic justification relative to the heating and cooling equipment sizing provisions contained in the proposed rule.

Fifth, the Department requests comments concerning suggestions on approaches for crediting measures that use renewable sources of energy.

Sixth, the Department requests comments on the appropriateness of the approach identified in section 435.402.1.6 of the proposed rule for dealing with equipment efficiencies under the whole building energy analysis compliance path in Subpart D.

Seventh, the Department requests comments on whether carbon dioxide alarms should be required in Federal residences.

Eighth, the Department requests comment on how this proposed rule could address equipment technologies for which a means of evaluating and comparing energy performance has not yet been fully developed.

Finally, as previously stated, the Department of Energy requests public review and comments on the draft EA.

C. Written Comment Procedures

Interested persons are invited to participate in this proceeding by submitting written data, views, or comments with respect to the proposed rulemaking.

Written comments (ten copies) shall be submitted to the address indicated in the **ADDRESSES** section of this notice. The copies must be received by the date indicated in the **DATES** section of this notice. Comments should be identified on both the outside of the envelope and on the documents themselves with the designation, *Energy Efficiency Code for New Federal Residential Buildings* (Docket No. EE–RM–96–300). In the event any person wishing to provide written comments cannot provide ten copies, alternative arrangements can be made in advance with the Department.

All comments received on or before the date specified at the beginning of this proposed rule and other relevant information will be considered by the Department before final action is taken on the proposed rule. All written comments will be available for examination in the Rule Docket File in the Department's Freedom of Information Office Reading Room at the address provided at the beginning of this document before and after the closing date for comments. In addition, a transcript of the proceedings of the public hearings will be filed in the docket.

Pursuant to the provisions of 10 CFR 1004.11, any person submitting information that is believed to be confidential, and which may be exempt by law from public disclosure, should submit one complete copy, and two copies from which the information believed to be confidential has been deleted. The Department will make its own determination of any such claim and treat it according to its determination.

D. Public Hearings

1. Procedure for Submitting Requests To Speak

To have the benefit of a broad range of public viewpoints in this rulemaking, the Department will hold a public hearing at the time and place indicated in the **DATES** and **ADDRESSES** sections of this notice. Any person who has an interest or who is a representative of a group or class of persons that has an interest in the proposed rule or the associated environmental assessment may request an opportunity to make an oral presentation. A request to speak at the public hearing must be mailed to the address or telephoned to the number indicated in the **ADDRESSES** section of this notice and received by the time specified in the **DATES** section of this notice.

The person making the request should briefly describe his or her interest in the proceedings and, if appropriate, state why that person is a proper representative of the group or class of persons that has such an interest. The person should also provide a telephone number where he or she may be contacted during the day. Each person selected to be heard will be notified by the Department as to the approximate time he or she will be speaking. Ten copies of the speaker's statement must be submitted at or before the hearing. In the event any person wishing to testify cannot meet this requirement, alternative arrangements can be made in advance with the Department.

2. Conduct of Hearings

The Department reserves the right to schedule persons to be heard at the hearing, to schedule their representative presentations, and to establish procedures governing the conduct of the hearing. The length of each presentation is limited to 15 minutes or otherwise based on the number of persons requesting an opportunity to speak.

A Department official will preside at the hearing. This will not be a judicial or evidentiary-type hearing. It will be conducted in accordance with 5 U.S.C. 553 and Section 501 of the Department of Energy Organization Act, 42 U.S.C. 7191. At the conclusion of all initial oral statements, each person who has made an oral statement will be given the opportunity to make a rebuttal or clarifying statement. The statements will be given in the order in which the initial statements were made and will be subject to time limitations.

Questions may be asked only by those conducting the hearing. Any interested person may submit to the presiding official written questions to be asked of any person making a statement at the hearing. The presiding official will determine whether the question is relevant or whether time limitations permit it to be presented for a response.

Any further procedural rules needed for the proper conduct of the hearing will be announced by the presiding official at the hearing.

A transcript of the hearing will be prepared by the Department and made available as part of the administrative record for this rulemaking. It will be on file for inspection at the Department's Freedom of Information Reading Room as provided at the address indicated at the beginning of this document.

If the Department must cancel the public hearing, the Department will make every effort to publish an advance notice of such cancellation in the **Federal Register**. The hearing date may be canceled, for example, in the event no member of the public requests the opportunity to make an oral presentation.

List of Subjects in 10 CFR Part 435

Buildings, Energy conservation, Energy efficiency, Engineers, Federal buildings and facilities, Housing.

Issued in Washington, DC, on April 1, 1997.

Brian T. Castelli,

Chief of Staff, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, Part 435 of Chapter II of Title 10 of the Code of Federal Regulations is proposed to be revised as set forth below:

PART 435—ENERGY EFFICIENCY CODE FOR NEW FEDERAL RESIDENTIAL BUILDINGS

Appendix to Part 435 Figures and Tables

Authority: 42 U.S.C. 6831–6832, 6834–6836; 42 U.S.C. 8253–54; 42 U.S.C. 7101, *et seq.*

§ 435.100 Explanation of numbering system for this part.

100.1 General. For the purposes of this part, a derivative of two different numbering systems will be used.

100.1.1 For the purpose of designating a section, the numbering system employed in the Code of Federal Regulations (CFR) will be employed. The number ''435'' which signifies part 435, Chapter II of Title 10, Code of Federal Regulations, is used as a prefix for all section headings. The suffix is a three digit number. For example, the life-cycle cost analysis section of this part is designated § 435.108.

100.1.2 Within each section, a numbering system common to many national voluntary consensus model codes is used. A decimal system is used to denote paragraphs and subparagraphs within a section. For example, 435.502.1.2 refers to subparagraph 2 of paragraph 1 of § 435.502.

100.2 The hybrid numbering system is used for two purposes:

100.2.1 The use of the Code of Federal Regulation numbering system allows the researcher using the CFR easy access to this part.

100.2.2 The use of the second system allows the builder, designer, architect or engineer easy access to the technical provisions because they are familiar with the numbering system and its format generally conforms to existing building codes. This system was chosen because of its commonality among the buildings industry.

Subpart A—Administration and Enforcement

§ 435.101 Scope and general requirements.

101.1 Title. This part shall be known as the Energy Efficiency Code for New Federal Residential Buildings and is referred to herein as ''this part.''

101.2 Purpose. The provisions of this part provide minimum standards for energy efficiency for the design of new Federal residential buildings. The performance standards are designed to achieve the maximum practicable cost-effective improvements in energy efficiency and increases in the use of non-depletable sources of energy. It is intended that these provisions provide flexibility to permit the use of innovative approaches and techniques to achieve efficient utilization of energy. This part also establishes minimum requirements for the control of radon in new Federal residential buildings.

101.3 Compliance. This part requires:

101.3.1 Use of a systems approach for the entire building and its energy-using subsystems which may utilize renewable sources as established in Subpart D or use of a component performance approach for various building elements and mechanical systems and components as established in subpart E; and

101.3.2 Compliance with the radon requirements is established in subpart G.

101.4 Scope. This part provides design requirements for building envelopes for adequate thermal resistance and low air leakage and the design and selection of mechanical, electrical, service water-heating and illumination systems and equipment which will enable efficient use of energy in new Federal residential building construction. It applies to the design and construction of all new Federal residential buildings that are three stories or less above grade that are not subject to state or local building codes. Federal residential buildings more than three stories above grade and all Federal nonresidential buildings must comply with the Energy Code for Federal Commercial and Multi-Family High-Rise Residential Buildings.

101.4.1 Radon control. This part also establishes requirements for control of radon for certain new Federal residential buildings. The applicability of those requirements is established in section 702.

101.4.2 Building types.

101.4.2.1 Group R Federal residential buildings. For the purposes of this part, Group R residential buildings include:

(a) Type A–1—Detached one and two family dwellings, and

(b) Type A–2—Other residential buildings, three stories or less in height.

101.4.2.2 Other buildings. Any buildings and structures not included in section 101.4.2.1 are not covered by this rule.

101.4.3 Exempt buildings. The building types that are exempt are as follows: assembly, health, and

101.4.3.1 Buildings and structures or portions thereof whose peak design rate of energy usage is less than 1.0 W (3.4 Btu/h) or 10.8 W/m^2 (1 W/ft^2) of floor area for all purposes.

101.4.3.2 Buildings and structures or portions thereof which are neither heated nor cooled.

101.4.4 Application to existing buildings.

101.4.4.1 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 part as they relate to new construction only.

§ 435.102 Materials and equipment.

102.1 Identification.

102.1.1 General. Materials and equipment shall be identified on the building plans and specifications in a manner that will allow for a determination of their compliance with the applicable provisions of this part.

102.1.2 Building envelope insulation. Building envelope insulation shall have a thermal resistance (R) identification marker on each piece of building envelope insulation 0.3048 m (12 in.) or greater in width. Alternatively, a signed and dated certification for the insulation installed in each element of the building envelope shall be provided, listing the type of insulation, the manufacturer, and the R-value. For blown-in or sprayed insulation, a certification shall be provided that identifies the initial installed thickness, the settled thickness, the coverage area, and the number of bags of insulation installed. The certification shall be posted in a conspicuous place on the job site.

102.1.3 Insulation installation. Roof-ceiling, floor, and wall-cavity insulation shall be installed to permit inspection of the manufacturer's R-value identification mark. Alternatively, the thickness of roof-ceiling insulation that is blown in or sprayed shall be identified by thickness markers that are labeled in meters (inches) and installed at least one every 27.9 m^2 (300 ft^2) of attic space. The markers shall be affixed to the roof trusses or ceiling joists and marked with the minimum installed thickness and minimum settled thickness using numbers 25.4 mm (1 in.) or greater in height. Each marker shall face the attic access opening. The thickness of installed insulation shall meet or exceed the minimum installed thickness shown by the marker.

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

102.3 Fenestration product rating, certification, and labeling. Fenestration products (windows, doors, and skylights) purchased by the Federal government shall have assigned U-values. If tested for U-value, the U-values of fenestration products (windows, doors, and skylights) shall be determined in accordance with RS–1, by an accredited, independent laboratory. The tested U-value of the fenestration product shall be certified and the certified U-value shall be labeled on a conspicuous place on the product. Such certified and labeled U-values shall be accepted for purposes of determining compliance with the building envelope requirements of this part.

102.3.1 Exception. Where a fenestration product has not been assigned a U-value in accordance with RS–1 for a particular product line, that product shall be assigned a default U-value in accordance with Appendix Tables 102.3.1 and 102.3.2. Product features must be technically verifiable for the product to qualify for the U-value associated with those features. Where the existence of a particular feature cannot be determined with reasonable certainty, the product shall not receive credit for that feature. Where a composite of materials from two different product types are used, the product shall be assigned the higher U-value.

§ 435.103 Alternate materials—method of construction, design, or insulation systems.

103.1 The provisions of this part 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 as meeting the intent of this part.

§ 435.104 [Reserved]

§ 435.105 [Reserved]

§ 435.106 [Reserved]

§ 435.107 Precedence.

107.1 When different sections of this part, or a section of this part and a section of a referenced standard from section 801 of this part, specify different materials, methods of construction, or other requirements, the more stringent or restrictive requirement shall govern. Whenever there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern.

§ 435.108 Life-cycle cost analysis.

108.1 The proposed building design(s) shall be evaluated in accordance with the requirements of the Federal Energy Management Program described in subpart A of 10 CFR part 436 to determine its life-cycle cost.

Subpart B—Definitions

§ 435.201 Definitions.

For the purposes of this part, certain abbreviations, terms, phrases, words and their derivatives shall be set forth in this section.

Accessible (as applied to equipment). Admitting close approach; not guarded by locked doors, elevation, or other effective means (see ''Readily accessible'').

Addition. Increase in conditioned floor area.

Air film. Air immediately adjacent to surfaces of building materials which helps to inhibit heat flow through those materials.

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 expressed in consistent units and under the designated operating conditions.

Attic. A space directly underneath the roof sheathing and directly above or adjacent to the interior surfaces of the topmost story of a building that satisfies all of the following conditions:

(1) The structural members comprising the roof are separate and distinct rafters and ceiling joists or truss assemblies;

(2) The space is ventilated in accordance with the requirements of the applicable building code;

(3) The clear height from the top of the ceiling joists to the highest point of the underside of the rafters is greater than 0.762 m (30 in.); and

(4) The space is provided with a readily accessible access in accordance with the requirements of the applicable building code.

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 also ''Manual'').

Basement wall. The opaque portion of a wall which encloses one side of a basement and is partially or totally below grade.

Building code. The legal instrument which is in effect in a state or unit of general purpose local government, the provisions of which must be adhered to if a building is to be considered to be in conformance with law and suitable for occupancy and use.

Building envelope. The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from spaces located in buildings exempted by the provisions of section 101.4.2.

Comfort 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.

Comfort envelope. The area of a psychrometric chart enclosing all those conditions described in Figure 1 in Standard RS–2 listed in section 801 as being comfortable.

Conditioned floor area. The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

Conditioned space. Space within a building which is provided with heated and/or cooled air or surfaces and, where required, with humidification or dehumidification means so as to be capable of maintaining a space condition falling within the comfort zone set forth by Standard RS–2 listed in section 801.

Cooled space. Space within a building which is provided with a positive cooling supply.

Crawl space wall. The opaque portion of a wall which encloses a crawl space and is partially or totally below grade.

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

Degree day, cooling. A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal cooling load of a building in summer. For any one day, when the mean temperature is greater than 18.3 °C (65 °F), there exists as many degree days as there are Celsius (Fahrenheit) degrees difference in temperature between the mean temperature for the day and 18.3 °C (65 °F).

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 18.3 °C (65 °F), there exists as many degree days as there are Celsius (Fahrenheit) degrees difference in temperature between the mean temperature for the day and 18.3 °C (65 °F).

Drain tile loop. A continuous length of drain tile or perforated pipe extending around all or part of the internal or external perimeter of a basement or crawl space footing.

Dwelling unit. A single housekeeping unit comprised of one or more rooms providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

Efficiency, HVAC system. The ratio of useful energy output (at the point of use) to the energy input in consistent units 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 Kilojoules [British thermal units (Btus)].

Energy source. Electricity, natural gas, propane gas or fuel oil that is available at a residential building for space heating, space cooling, service water heating and lighting. See also ''Renewable energy sources.''

Equipment type. HVAC system equipment or service water heating equipment that (1) performs a specific function(s) (e.g., space heating or space heating and service water heating), (2) uses a specific energy source(s) (e.g., electricity or a ''dual-fuel'' furnace that can use electricity or natural gas), and (3) employs a specific operational principle (e.g., direct combustion, heat rejection to air, heat extraction from ground water). Example: A heat pump water heater is a different equipment type from an electric resistance water heater.

Exterior envelope. See ''Building envelope.''

Federal agency. Any department, agency, corporation, or other entity or instrumentality of the executive branch of the Federal government, including the United States Postal Service, the Federal National Mortgage Association, and the Federal Home Loan Mortgage Corporation.

Federal residential building. Any detached one- or two-family residential dwelling or other residential building or structure, three stories or less in height, to be constructed or developed for residential occupancy by, or for the use of, any Federal agency that is not legally subject to state or local building codes or similar requirements.

Furnace, duct. A furnace normally installed in distribution ducts of air conditioning systems to supply warm air for heating and which depends on a blower not furnished as part of the duct furnace for air circulation.

Furnace, warm air. A self-contained, indirect-fired or electrically heated furnace that supplies heated air through ducts to spaces that require it.

Glazing area. Interior surface area of assemblies that enclose conditioned space and that contain glazing, such as windows, sliding glass doors, and skylights, including the frame, sash, curbing, muntins, and other framing element.

Grade. The finished ground level adjoining the building at all exterior walls.

Gross area of exterior walls. The normal projection of the building envelope wall area bounding interior space which is conditioned by an energy-using system, including opaque wall, window and door area. The gross area of exterior walls consists of all opaque wall areas, including between floor spandrels, peripheral edges of floors, window areas including sash, and door areas, where such surfaces are exposed to outdoor air, unconditioned spaces, or spaces exempted by section 101.4.2, and where such spaces enclose a heated or mechanically cooled space, including interstitial areas between two such spaces. For each basement wall with an average below-grade area less than 50% of its total wall area, including openings, the entire wall, including the below-grade portion, is included as part of the gross area of exterior walls. Nonopaque areas (windows, doors, etc.) of all basement walls are included in the gross area of exterior walls.

Gross floor area. The sum of the areas of the several floors of the building, including basements, cellars, mezzanine and intermediate floored tiers and penthouses of headroom height, measured from the exterior faces of exterior walls or from the center line of walls separating buildings, but excluding:

(a) Covered walkways, open roofed-over areas, porches and similar spaces.

(b) Pipe trenches, exterior terraces or steps, chimneys, roof overhangs and similar features.

Group R Federal residential buildings. For the purpose of this part, Group R Federal residential buildings include:

(a) Type A–1—Detached one and two family dwellings; and,

(b) Type A–2—Other Federal residential buildings, three stories or less in height.

Heat. The form of energy that is transferred by virtue of a temperature difference or a change in state of a material.

Heat trap. An arrangement of piping connecting to a hot water heater such that the piping makes an inverted ''U'' just before connecting to the heater fittings. Any other arrangement, including a commercially available heat trap, which effectively restricts the natural tendency of hot water to rise also qualifies as a heat trap.

Heated slab. Slab-on-grade construction in which the heating elements or hot air distribution system is in contact with or placed within the slab or in the subgrade.

Heated space. Space within a building which is provided with a positive heat supply. Finished living space within a basement with registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space.

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

HVAC. Heating, ventilating and air conditioning.

HVAC system. The equipment, distribution network, and terminals that provide, either collectively or individually, the processes of heating, ventilating, or air conditioning to a building.

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

HVAC system efficiency. See ''Efficiency, HVAC system.''

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

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.

Life-cycle cost. The total discounted cost of owning, operating, and maintaining a building or piece of equipment over its useful life (including its fuel, energy, labor, and replacement components) determined on the basis of a systematic evaluation except that in the case of leased buildings, the life-cycle cost shall be calculated over the effective remaining term of the lease.

Manual. Capable of being operated by personal intervention (see ''Automatic'').

Multi-family dwelling. A building containing three or more dwelling units.

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

Outdoor air. Air taken from the outdoors and, therefore, not previously circulated through the system.

Packaged terminal air conditioner. A factory-selected wall sleeve and separate unencased combination of heating and cooling components, assemblies or sections intended for mounting through the wall to serve a single room or zone. It includes heating capability by hot water, steam, or electricity.

Packaged terminal heat pump. A packaged terminal air conditioner capable of using the refrigeration system in a reverse cycle or heat pump mode to provide heat.

pCi/L. The abbreviation for ''picocuries per liter,'' which is used as a measure for radon concentrations in air. A picocurie is one-trillionth (10^{-12}) of a curie. A ''curie'' is a commonly used measurement of radioactivity.

Positive cooling supply. Mechanical cooling deliberately supplied to a space such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space-cooling components, such as evaporator coil cases and cooling distribution systems which continually maintain air temperatures within the space of 29.4 °C (85 °F) or lower during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this part.

Positive heat supply. Heat deliberately supplied to a space by design, such as a supply register, radiator or heating element. Also, heat indirectly supplied to a space through uninsulated surfaces of service water heaters and space heating components, such as furnaces, boilers and heating and cooling distribution systems which continually maintain air temperature within the space of 10 °C (50 °F) or higher during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this part.

Proposed design. A building design submitted in response to a request for proposals for the construction of a new Federal residential building.

Readily accessible. Capable of being reached quickly for operation, maintenance, removal, or inspection, without requiring the need to climb over or remove obstacles or to resort to portable ladders or chairs (see ''Accessible'').

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

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

Roof assembly. All components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to 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.

Sash crack. The sum of all perimeters of all window sashes, based on overall dimensions of such parts, expressed in meters (feet). If a portion of one sash perimeter overlaps a portion of another sash perimeter, only count the length of the overlapping portions once.

Sensible capacity. The maximum sensible load for which a piece of equipment is designed to remove or add sensible heat.

Sensible load. The cooling or heating load to remove or add the sensible heat that causes a temperature change.

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 purposes other than comfort heating.

Slab-on-grade floor insulation. Insulation around the perimeter of the floor slab or its supporting foundation when the top edge of the floor slab perimeter is above the finished grade or 0.305 m (12 in.) or less below the finished grade.

Soil gas. The gas, present in soil, which may contain radon.

Soil gas retarder. A continuous membrane or other comparable material used to retard the flow of soil gas into a building.

Solar energy source. Source of natural daylighting and of thermal, chemical or electrical energy derived directly from conversion of incident solar radiation.

Standard design. A building designed to exactly meet but not exceed all requirements in Subpart E of this part.

Submembrane depressurization system. A system designed to achieve a lower air pressure beneath the soil gas retarder in a crawl space, relative to crawl space air pressure, resulting in air withdrawal from under the soil gas retarder either passively (relying on the upward convective flow of air) or actively (by use of a fan-powered vent).

Subslab depressurization system (active). A piping system that connects the subslab area with outdoor air, is routed through the conditioned space of a building, and uses a fan-powered vent to draw air from beneath the slab.

Subslab depressurization system (passive). A piping system that connects the subslab area with outdoor air, is routed through the conditioned space of a building, and relies on the convective flow of air to draw air from beneath the slab.

Supplementary heater operation. The auxiliary electric resistance heating device that provides heat which contributes to the operation of the heat pump when the temperature is too low for the heat pump to operate independently.

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.

Technically verifiable. To visually, physically, or through testing determine the physical characteristics or specifications of an element, material, or object.

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

Thermal conductance. Time rate of heat flow through a body (frequently per unit area) from one bounding surface to the other for a unit temperature difference between the two surfaces, under steady conditions (W/m²·°C) [Btu/(h·ft²·°F)].

Thermal resistance (R). The reciprocal of thermal conductance (m²·°C/W) [(h·ft²·°F)/Btu].

Thermal transmittance (U). The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (W/m²·°C) [Btu/(h·ft²·°F)]. The U-value applies to combinations of different materials used in series along the heat flow path, single materials that comprise a building section, cavity air spaces and surface air films on both sides of a building element.

Thermal transmittance, overall (U_o). The overall (average) heat transmission of a gross area of exterior building envelope (W/m²·°C) [Btu/(h·ft²·°F)]. The U_o value applies to the combined effect of the time rate of heat flow 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/ceilings.

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

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

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

Ventilation. The process of supplying or removing air by natural or mechanical means to or from any space. Such air may have been conditioned.

Ventilation air. That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. (See Standard RS–3 listed in section 801 of this part, and definition of ''Outdoor air''.)

Walls. Those portions of the building envelope which are vertical or tilted at an angle of 30° or less from the vertical plane.

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.

Subpart C—Design Conditions

§ 435.301 Scope.

301.1 General. The criteria of this subpart establishes the design conditions for use with Subparts D and E of this part.

§ 435.302 Thermal design parameters.

302.1 Exterior design conditions. The following design parameters from table 302.1 shall be used for calculations required under this part.

TABLE 302.1

[Exterior design conditions]

Winter[1]	Design Dry-bulb	°C (°F).
Summer[1]	Design Dry-bulb	°C (°F).
	Design Wet-bulb	°C (°F).
Degree days, heating[2]		
Degree days, cooling[2]		

[1] The outdoor design temperature shall be selected from the columns of 97.5% values for winter and 2.5% values for summer from tables in Standard RS–4 listed in section 801. Adjustments may be made to reflect local climates which differ from the tabulated temperatures, or local weather experience.

[2] The degree days, heating [base 18.3°C (65°F)] and cooling [base 18.3°C (65°F)] shall be selected from *NOAA Annual Degree Days to Selected Bases Derived from the 1961—1990 Normals,* Standard RS–4 listed in section 801, data available from adjacent military installations, or other sources of local data.

302.2 Interior design conditions.

302.2.1 Indoor Design Temperature. Indoor design temperature shall be 22.2°C (72°F) for heating and 25.6°C (78°F) for cooling.

302.2.2 Exception. Other design temperatures may be used for equipment selection if it results in a lower energy usage.

§ 435.303 Mechanical ventilation criteria.

303.1 Ventilation. Ventilation air shall conform to Standard RS–3 listed in section 801. The minimum column value of Standard RS–3 for each type of occupancy shall be used for design. The ventilation quantities specified in section 6 of Standard RS–3 are for 100% outdoor air ventilating systems.

303.1.1 Exception. If outdoor air quantities other than those specified in Standard 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.

Subpart D—Design by Systems Analysis; Design Utilizing Renewable Energy Sources

§ 435.401 Scope.

401.1 General. This subpart establishes design requirements based on a systems analysis of total energy use by a new Federal residential building, including all of its systems. These design requirements may be applied as an alternative to the component performance requirements established in subpart E.

§ 435.402 Systems analysis.

402.1 Energy analysis. Compliance with this subpart requires an analysis of the annual energy usage, hereinafter called an annual energy analysis. The proposed building shall utilize a design that is demonstrated, through technically valid and documented calculations, to have equal or lower annual energy use and equal or lower life-cycle costs than the standard design.

(a) A building designed in accordance with this subpart complies with this part if the calculated annual energy usage and life-cycle costs are not greater than a similar building (defined as a ''standard design'') with building thermal envelope components and mechanical systems and equipment used to provide heating, ventilating, and air-conditioning designed in accordance with subpart E.

(b) For a proposed building to be considered similar to a ''standard design,'' the proposed building shall have the same conditioned floor area, ratio of thermal envelope area to conditioned floor area, exterior design conditions, occupancy, climate data, and usage operational schedule.

(c) The proposed design shall use the same energy source(s) for space heating, space cooling, and domestic water heating as the standard design (identified in subpart E).

402.1.1 Input values for Group R buildings. The input values/assumptions from tables 402.1.1a through 402.1.1g shall be used in calculating the annual energy usage.

TABLE 402.1.1a

[Glazing systems]

Input Assumptions		
Design Parameter	Standard Design	Proposed Design
Glazing Orientation	Window area of proposed house, 25% on North, South, East, and West Exterior walls..	Window area oriented as proposed design.
Shading	Draperies shall be assumed to be closed during period of mechanical air conditioner operation..	Any exterior shading provided by proposed design.

TABLE 402.1.1b

[Heat storage (thermal mass)]

Internal mass	39.0 kg/m² (8 lb/ft²)
Structural mass.	17.1 kg/m² (3.5 lb/ft²)

TABLE 402.1.1c

[Building thermal envelope—surface areas and volume]

Design parameter	Input assumptions
Floor, walls, ceiling.	The floor, walls, and ceiling areas for both the standard and proposed design(s) shall be equal.
Foundation and floor type.	The foundation and floor type for both the standard and the proposed design(s) shall be equal.
Glazings, including skylights.	The area of glazing in the standard design shall not be greater than the area of glazing in the proposed design(s). The glazing U-value of the standard design shall be selected to permit calculated U_o-wall compliance of the standard design. Glazing area in the standard design shall not be provided with extra shading beyond shading that is provided by typical construction practices—such as roof overhangs. Energy performance impacts of added shading for glazing areas may be accounted for in the proposed design(s) for a specific building. Results from shading calculation on one proposed building shall not be used for groups of buildings.
Doors of A–1 structures.	The standard design shall have at least 3.7 m² (40 ft²) of door area.

TABLE 402.1.1c—Continued

[Building thermal envelope—surface areas and volume]

Design parameter	Input assumptions
Building Volume.	The volumes of both the standard and proposed design(s) shall be equal.

TABLE 402.1.1d

[Thermostat (constants)]

Design parameter	Input value
Heating Set Point	20.0 °C (68 °F).
Cooling Set Point	25.6 *C (78 *F).
Night Set Back	15.6 *C (60 *F).
Set Back Duration	7 hours.
Number of Set-back Periods.	1 (night time).
Maximum number of zones.	2.
Number of thermostats per zone.	1.

TABLE 402.1.1e

[Internal Sensible Heat Gains (Constants)]

Unit type	Input value
A–1 Units	440 W (1,500 Btu/h)
A–2 Units	879 W (3,000 Btu/h)

TABLE 402.1.1f

[Domestic Water Heater (Constant, Calculation)]

Design parameter	Input value
Temperature set point.	49 °C (120 °F)
Daily hot water consumption.	Liters=113.7×n-units+(37.9×n-bedrooms); [Gallons=(30×n-units)+(10×n-bedrooms)]

Note:

n-units=number of living units in proposed design(s)

n-bedrooms=number of bedrooms in each living unit.

TABLE 402.1.1g

[Distribution System Loss Factors]

Duct Location		
Mode	Outside	Inside
Heating	0.75	1.00
Cooling	0.80	1.00

402.1.2 If the proposed design takes credit for reduced air changes per hour levels, documentation of measures providing such reduction, or results of a post-construction blower-door test shall be demonstrated using Standard RS–5 listed in section 801.

402.1.3 Passive solar building designs shall have fixed external shading, operable internal or external shading or other shading technologies to limit excessive summer cooling energy gains to the building interior.

402.1.4 Passive solar buildings shall utilize at least 919 kJ/°C (45 Btu/°F) of additional thermal mass, per m² (ft²) of added glass area, when added south-facing glass area exceeds 33% of the total glass area in walls.

402.1.5 Site Weather Data (constants).

402.1.5.1 The typical meteorological year (TMY), or its ''ersatz'' equivalent, from the National Oceanic and Atmospheric Administration (NOAA), or an approved equivalent, for the closest available location shall be used.

402.1.6 The HVAC System Efficiency, for heating and cooling mode, as identified in 10 CFR part 430 shall be proportionally adjusted for those portions of the ductwork located outside or inside the conditioned space using the values shown above, in accordance with equation 402.1a and table 402.1g:

(Equation 402.1.6a)

Total Adjusted System Efficiency=Equipment Efficiency × Distribution Loss Factor × percent of ducts outside+Equipment Efficiency × Distribution Loss Factor × percent of ducts inside.

402.1.7 Air infiltration. Air changes per hour for the standard design is 0.5 (for purposes of calculation only).

402.2 Design. The energy usage of the standard design and the proposed design shall be compared as follows:

(a) The comparison shall be expressed as joule per square meter (Btu input per square foot) of gross floor area per year at building site.

(b) If the proposed design results in an increase in usage 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.

(c) The different energy sources shall be compared on the basis of energy use at the site where: 1 kWh=3,413 Btu.

402.3 Analysis procedure. The analysis of the annual energy usage of the standard design and the proposed design(s) shall meet the following criteria:

(a) The building heating/cooling load calculation procedure used for annual energy usage analysis shall be detailed enough to evaluate the 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 evaluate the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data shall be used when available in the simulation of systems and equipment. The calculation procedure shall be based upon 8,760 hours of operation of the building and its service systems and shall utilize the design methods specified in Standards RS–4, –6, and –7 listed in section 801.

402.4 Calculation procedures. The calculation procedure shall cover the following items:

(a) Design requirements—Environmental requirements as required in subpart C.

(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.

402.4.1 Use of approved calculation tool. The same calculation tool shall be used to estimate the annual energy usage for space heating and cooling of the standard design and the proposed design(s).

402.5 Documentation. Proposed design(s) shall have an energy analysis comparison report providing technical detail 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 401 of this part.

402.6 Exception. Proposed design(s) for one and two family dwellings and multifamily buildings having a conditioned floor area of 465 m^2 (5,000 ft^2) or less are exempted from performing an analysis on a full-year (8760 hours) basis as described in section 402.3(b). However, comparison of heating, cooling, and service water heating equipment energy usage between the proposed design(s) and the standard design shall be provided in accordance with the remaining provisions of section 402 of this part.

§ 435.403 Renewable energy source analysis.

403.1 General. A proposed building utilizing solar, geothermal, wind or other renewable energy sources for all or part of its energy source shall meet the requirements of section 402 of this part, except such renewable energy may be excluded from the total annual energy usage allowed for the building by that section.

403.1.1 To qualify for this exclusion such renewable 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:

(a) Operable insulating shutters or other devices which, when drawn or closed, shall cause the window area to reduce maximum outward heat flow rate to that specified in section 502.3.1; and

(b) The window areas are shaded or otherwise protected from direct rays of the sun during periods when mechanical cooling is required.

403.1.2 Exclusion shall also be granted for solar energy passing through windows provided:

(a) The glass is double or triple pane insulating glass with a low-emittance coating on one or more airspace surfaces of the glass, or with a low-emittance plastic film suspended in the airspace, and

(b) The glass areas are shaded from direct solar radiation during periods when mechanical cooling is required.

403.1.3 Other criteria covered in section 402 shall apply to the proposed design(s) utilizing renewable sources of energy.

403.2 Documentation. An annual energy analysis comparison shall be prepared comparing the proposed design(s) and the standard design as specified in section 402. The report shall provide technical detail on the building and system design(s) and on the data employed in the comparative analysis sufficient to verify that both the analysis and the proposed design(s) meet the criteria of sections 402 and 403 of this part.

403.2.1 The energy derived from renewable 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 renewable energy sources or nocturnal cooling shall be demonstrated in the building plans and specifications.

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

403.3 Exception. Proposed design(s) for buildings of less than 464m^2 (5,000 ft^2) of conditioned floor area that derive a minimum of 30% of their total annual energy usage from renewable sources or from nocturnal cooling are exempt from performing the analysis on a full-year (8,760 hours) basis as described in section 402.3(b). However, comparison of heating, cooling, and service water heating equipment energy usage between the proposed design(s) and the standard design shall be provided in accordance with the remaining provisions of sections 402 and 403 of this part.

403.4 Passive solar design analysis. Proposed design(s) using passive solar heating strategies, such as south window placement coupled with thermal mass, attached greenhouses or sunspaces, or Trombe walls, can be analyzed for annual heating and cooling loads using RS–8. Other methods for analysis of solar design strategies and equipment are permitted. Note that use of RS–8 provides information on building loads only; actual energy consumption depends on the equipment proposed for installation in the building.

Subpart E—Design by Component Performance Approach

§ 435.501 Scope.

501.1 General. This subpart establishes design requirements based on component performance for new Federal residential buildings. The design requirements established in subpart D may be applied in lieu of these requirements.

§ 435.502 Building thermal envelope requirements.

502.1 General. The building thermal envelope shall meet the requirements of table 502.1a. Compliance with these requirements shall be demonstrated in accordance with section 502.2. To demonstrate compliance, calculation procedures and information contained in RS–4, or laboratory test measurements obtained from test methods RS–9, –10, –11, or –12, or other documented procedures or information, shall be used.

502.1.1 The proposed design may include the use of thermal mass in the exterior walls when determining energy use. If the use of thermal mass is considered appropriate in the design of the exterior walls then the required U_W for exterior walls, covered by section 502.2.1.1 and having a heat capacity greater than or equal to 123 kJ/m^2·°K (6 Btu/ft^2·°F), shall be less than or equal to the U-value determined by the applicable heating degree-days and low-mass-wall U_W in tables 502.1b, 502.1c, or 502.1d. The column headings in tables 502.1b through 502.1d are the U_W's, as determined by using equation 502.2a and Appendix Figure 1, for low-mass-walls; wall constructions having a heat capacity of less than 123 kJ/m^2·°K (6 Btu/ft^2·°F), as determined by equation 502.1a. The heat capacity of the wall shall be determined by using equation 502.1a below:

(Equation 502.1a)

$$HC = w \times c$$

where:

HC=heat capacity of the exterior wall, based on exterior surface area, W/(m^2·°K) [Btu/(ft2·°F)].

w=mass of the wall, based on exterior surface area, kg/m^2 (lb/ft^2).

c=specific heat of the exterior wall material, kJ/(kg·°K) [Btu/(lb·°F)].

The specific heat values shall be permitted to be obtained from Chapter 22 of Standard RS–4.

TABLE 502.1A [1]

Element	Mode	Type A–1 buildings	Type A–2 buildings
Walls	Heating or cooling	$U_o \leq$	$U_o \leq$
Roof/Ceiling	Heating or cooling	$U_o \leq$	$U_o \leq$
Floors over unheated spaces	Heating or cooling	$U^o \leq$	$U_o \leq$
Heated slab on grade [2 5]	Heating	R≥ Depth ≥ in.[6]	R≥ Depth ≥ in.[6]
Unheating slab on grade [3 5]	Heating	R≥ Depth ≥ in.[6]	R≥ Depth ≥ in.[6]
Basement wall [4 5]	Heating or cooling	U≤	U≤
Crawl space wall [4 5]	Heating or cooling	U≤	U≤

[1] Values shall be determined by using the graphs (Figures 1, 2, 3, 4, 5 and 6) contained in the Appendix of this part using heating degree days as specified in section 302.

[2] There are no insulation requirements for heated slabs in locations having less than 278 Celsius heating degree days (500 Fahrenheit HDD).

[3] There are no insulation requirements for unheated slabs in locations having less than 1,389 Celsius heating degree days (2,500 Fahrenheit HDD).

[4] Basement and crawl space wall U-values shall be based on the wall components and surface air films. Adjacent soil shall not be considered in the determination of the U-value.

[5] Typical foundation wall insulation techniques can be found in Standard RS–13.

[6] Depth of burial measured as described in section 502.2.1.4.

TABLE 502.1B.—REQUIRED U_w FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 123 KJ/(M^2·°K) [6 BTU/(FT^2·°F)] WITH INSULATION PLACED ON THE EXTERIOR OF THE WALL MASS

Heating degree days 18.3 °C (65 °F) base	U_W required for walls with a heat capacity less than 123 kJ/(m^2·°K) [6 Btu/(ft^2·°F)] as determined by using equation 502.2a and appendix figure 1								
	1.13 (0.20)	1.02 (0.18)	0.90 (0.16)	0.79 (0.14)	0.68 (0.12)	0.56 (0.10)	0.45 (0.08)	0.34 (0.06)	0.22 (0.04)
0–1111	1.59	1.47	1.30	1.19	1.02	0.90	0.73	0.62	0.45
(0–2000)	(0.28)	(0.26)	(0.23)	(0.21)	(0.18)	(0.16)	(0.13)	(0.11)	(0.08)
1112–2222	1.53	1.42	1.24	1.13	0.96	0.85	0.73	0.56	0.45
(2001–4000)	(0.27)	(0.25)	(0.22)	(0.20)	(0.17)	(0.15)	(0.13)	(0.10)	(0.08)
2223–3056	1.42	1.30	1.19	1.02	0.90	0.79	0.62	0.51	0.39
(4001–5500)	(0.25)	(0.23)	(0.21)	(0.18)	(0.16)	(0.14)	(0.11)	(0.09)	(0.07)
3056–3611	1.30	1.19	1.07	0.96	0.85	0.68	0.56	0.45	0.34
(5501–6500)	(0.23)	(0.21)	(0.19)	(0.17)	(0.15)	(0.12)	(0.10)	(0.08)	(0.06)
3612–4444	1.24	1.07	0.96	0.85	0.73	0.62	0.51	0.39	0.28
(6501–8000)	(0.22)	(0.19)	(0.17)	(0.15)	(0.13)	(0.11)	(0.09)	(0.07)	(0.05)
>4445	1.13	1.02	0.90	0.79	0.68	0.56	0.45	0.34	0.22
(>8001)	(0.20)	(0.18)	(0.16)	(0.14)	(0.12)	(0.10)	(0.08)	(0.06)	(0.04)

TABLE 502.1C.—REQUIRED U_w FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 123KJ/(M^2·°K) [6BTU/(FT^2·°F) WITH INSULATION PLACED ON THE INTERIOR OF THE WALL MASS

Heating degree days 18.3°C (65°F) base	U_w required for walls with a heat capacity less than 123 kJ/(m^2·°K) [6 Btu/(ft^2·°F)] as determined by using equation 502.2a and appendix figure 1								
	1.13 (0.20)	1.02 (0.18)	0.90 (0.16)	0.79 (0.14)	0.68 (0.12)	0.56 (0.10)	0.45 (0.08)	0.34 (0.06)	0.22 (0.04)
0–1111	1.42	1.24	1.13	0.96	0.85	0.68	0.51	0.39	0.22
(0–2000)	(0.25)	(0.22)	(0.20)	(0.17)	(0.15)	(0.12)	(0.09)	(0.07)	(0.04)
1112–2222	1.36	1.19	1.07	0.90	0.79	0.68	0.51	0.39	0.22
(2001–4000)	(0.24)	(0.21)	(0.19)	(0.16)	(0.14)	(0.12)	(0.09)	(0.07)	(0.04)
2223–3056	1.30	1.19	1.07	0.90	0.79	0.62	0.51	0.39	0.22
(4001–5500)	(0.23)	(0.21)	(0.19)	(0.16)	(0.14)	(0.11)	(0.09)	(0.07)	(0.04)
3056–3611	1.24	1.13	0.96	0.85	0.73	0.62	0.51	0.34	0.22
(5501–6500)	(0.22)	(0.20)	(0.17)	(0.15)	(0.13)	(0.11)	(0.09)	(0.06)	(0.04)
3612–4444	1.19	1.07	0.96	0.79	0.68	0.56	0.45	0.34	0.22
(6501–8000)	(0.21)	(0.19)	(0.17)	(0.14)	(0.12)	(0.10)	(0.08)	(0.06)	(0.04)
>4445	1.13	1.02	0.90	0.79	0.68	0.56	0.45	0.34	0.22
(>8001)	(0.20)	(0.18)	(0.16)	(0.14)	(0.12)	(0.10)	(0.08)	(0.06)	(0.04)

TABLE 502.1D.—REQUIRED U_w FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 123KJ/(M^2·°K) [6BTU/(FT^2·°F) WITH INTEGRAL INSULATION (INSULATION AND MASS MIXED, SUCH AS A LOG WALL)

Heating degree days 18.3°C (65°F) base	U_w required for walls with a heat capacity less than 123 kJ/(m^2·°K) [6 Btu/(ft^2·°F)] as determined by using equation 502.2a and appendix figure 1								
	1.13 (0.20)	1.02 (0.18)	0.90 (0.16)	0.79 (0.14)	0.68 (0.12)	0.56 (0.10)	0.45 (0.08)	0.34 (0.06)	0.22 (0.04)
0–1111	1.59	1.42	1.30	1.13	0.96	0.85	0.68	0.51	0.39
(0–2000)	(0.28)	(0.25)	(0.23)	(0.20)	(0.17)	(0.15)	(0.12)	(0.09)	(0.07)
1112–2222	1.53	1.36	1.24	1.07	0.96	0.79	0.62	0.51	0.34
(2001–4000)	(0.27)	(0.24)	(0.22)	(0.19)	(0.17)	(0.14)	(0.11)	(0.09)	(0.06)
2223–3056	1.47	1.30	1.19	1.02	0.90	0.73	0.62	0.45	0.34
(4001–5500)	(0.26)	(0.23)	(0.21)	(0.18)	(0.16)	(0.13)	(0.11)	(0.08)	(0.06)
3056–3611	1.36	1.19	1.07	0.96	0.79	0.68	0.56	0.45	0.28
(5501–6500)	(0.24)	(0.21)	(0.19)	(0.17)	(0.14)	(0.12)	(1.10)	(0.08)	(0.05)
3612–4444	1.24	1.13	1.02	0.85	0.73	0.62	0.51	0.39	0.28
(6501–8000)	(0.22)	(0.20)	(0.18)	(0.15)	(0.13)	(0.11)	(0.09)	(0.07)	(0.05)
>4445	1.13	1.02	0.90	0.79	0.68	0.56	0.45	0.34	0.22
(>8001)	(0.20)	(0.18)	(0.16)	(0.14)	(0.12)	(0.10)	(0.08)	(0.06)	(0.04)

502.1.2 The design shall not create conditions of accelerated deterioration from moisture condensation. For frame walls, floors, and ceilings not ventilated to allow moisture to escape, an approved vapor retarder having a maximum perm rating of 57.4 ng/Pa·s·m^2 (1.0 perm), when tested in accordance with Standard RS–14, Procedure A, shall be installed on the warm-in-winter side of the thermal insulation.

502.1.3 Exceptions.

502.1.3.1 Buildings are exempt from the requirements of section 502.1.2 in construction where moisture or its freezing will not damage the materials.

502.1.3.2 Buildings are exempt from the requirements of section 502.1.2 in hot and humid climate areas where the following conditions occur:

(a) 19.4 °C (67 °F) or higher wet-bulb temperature for 3,000 or more hours during the warmest six consecutive months of the year, and/or

(b) 22.8 °C (73 °F) or higher wet-bulb temperature for 1,500 or more hours during the warmest six consecutive months of the year.

502.1.4 Access openings. Access doors, hatches, scuttles, pull-down staircases and similar constructions separating a conditioned from an unconditioned space shall be weatherstripped along the surfaces that seal to the surrounding fixed frame. The access opening shall be insulated to a level equivalent to the insulation of the surrounding floor, wall, and ceiling.

502.1.4.1 Exception. If the access opening is uninsulated, the U-value of the surrounding floor, wall, and ceiling shall be decreased in accordance with equations 502.2a, 502.2b, 502.2c, or 502.2d, as appropriate.

502.1.5 Masonry Veneer. When insulation is placed on a foundation wall, and part of the foundation wall supports a masonry veneer for the exterior wall, the horizontal portion of the foundation supporting the veneer need not be insulated.

502.2 Heating and cooling criteria.

502.2.1 Compliance by performance on an individual component basis. Each component of the building envelope shall meet the provisions of table 502.1a as provided in sections 502.2.1.1—502.2.1.6.

502.2.1.1 Walls.

502.2.1.1.1 Conventional framing. The combined thermal transmittance value (U_O) of the gross area of exterior walls shall not exceed the value given in table 502.1a. Equation 502.2a shall be used to determine acceptable combinations to meet this requirement.

$$U_o = \frac{(U_w A_w) + (U_g A_g) + (U_d A_d)}{A_o} \quad \text{(Equation 502.2a)}$$

where:

U_o=the average thermal transmittance of the gross area of exterior walls.

A_o=the gross area of exterior walls.

U_w=the combined thermal transmittance of the various paths of heat transfer through the opaque exterior wall area.

A_w=area of exterior wall that is opaque.

U_g=the thermal transmittance of the area of all windows within the gross wall area as determined in accordance with section 102.3 of this part.

A_g=the area of all windows within the gross wall area.

U_d=the thermal transmittance of the area of all doors within the gross wall area as determined in accordance with section 102.3 of this part.

A_d=the area of all doors within the gross wall area.

When more than one type of wall, window, or door is used, the U × A term for that item shall be expanded into sub-elements as:

$U_w A_w = (U_{w1} A_{w1}) + (U_{w2} A_{w2}) + (U_{w3} A_{w3}) + \ldots$ (etc.)

502.2.1.1.2 Metal framing. When exterior walls are framed with metal studs, calculate the value of U_w used in equation 502.2b as follows:

where:

R_s=the total thermal resistance of the elements, in series along the path comprising the wall assembly of heat transfer, excluding the cavity insulation and the metal stud.

R_{ins}=the R value of the cavity insulation

F_c=the correction factor listed in Appendix table 502.2.1.1.2.

$$U_w = \frac{1}{R_s + (R_{ins} \times F_c)} \quad \text{(Equation 502.2b)}$$

502.2.1.1.3 Any vertical glazing assemblies or vertical walls that form part of a roof assembly that bounds conditioned space, such as clerestories and dormers, shall be treated as part of the exterior wall area for purposes of complying with this part.

502.2.1.2 Roof/ceiling. The combined thermal transmittance value (UO) of the gross area of the roof or ceiling assembly shall not exceed the value given in table 502.1a. Equation 502.2c shall be used to determine acceptable combinations to meet this requirement.

$$U_O = \frac{(U_R \times A_R) + (U_S \times A_S)}{A_O} \quad \text{(Equation 502.2c)}$$

where:

U_o=the average thermal transmittance of the gross roof/ceiling area.

A_o=the gross area of the roof/ceiling assembly.

U_R=the thermal transmittance of all elements of the opaque roof/ceiling area.

A_R=area of the opaque roof/ceiling assembly.

U_s=the thermal transmittance of the area of all skylight elements in the roof/ceiling assembly as determined in accordance with section 102.3 of this part.

A_s=the area (including frame) of all skylights within the roof/ceiling assembly.

When more than one type of roof/ceiling or skylight is used, the U × A term for that item shall be expanded into its sub-elements, as:

$U_R \times A_R = (U_{R1} \times A_{R1}) + (U_{R2} \times A_{R2}) + \ldots$etc.

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

(a) For thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly and, b) For gross area purposes, be based upon the interior face of the upper plenum surface.

502.2.1.3 Floors over unheated spaces. The combined thermal transmittance value (U_O) of the gross area of floors over unheated spaces shall not exceed the value given in table 502.1a. The thermal transmittance requirement of this section does not apply to floors over unvented crawl spaces and basements if the requirements of section 502.2.1.5 and/or 502.2.1.6 are met. For floors over outdoor air, e.g., overhangs, the U_O value shall meet the same requirement shown for roofs in table 502.1a. Equation 502.2d shall be used to determine acceptable combinations to meet this requirement.

$$U_O = \frac{(U_{f1} \times A_{f1}) + (U_{f2} \times A_{f2}) + \cdots (U_{fn} A_{fn})}{A_O} \quad \text{(Equation 502.2d)}$$

where:

U_O=the combined thermal transmittance of the different floor assemblies.

A_O=the gross area of all floor assemblies.

$U_{1,\ldots,n}$=the thermal transmittance of the various heat transfer paths through the first (or nth) floor assembly.

$A_{f1,\ldots,fn}$=the area of the first (or nth) floor assembly.

502.2.1.4 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 502.1a. Insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. In climates below 3,333 annual Celsius heating degree days (HDD) (6,000 annual Fahrenheit HDD), the insulation shall extend downward from the top of the slab for a minimum distance of 0.610 m (24 in.) or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 0.610 m (24 in.) and shall be designed for ground contact. In climates equal to or greater than 3,333 annual Celsius heating degree days (HDD) (6,000 annual Fahrenheit HDD), the insulation shall extend downward from the top of the slab for a minimum of 1.22 m (48 in.) or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 1.22 m (48 in.). In all climates, horizontal insulation extending outside of the foundation shall be covered by pavement or soil a minimum of 0.254 m (10 in.) thick. If the insulation is placed to the inside of the foundation wall, there must be insulation placed between the slab and the foundation wall. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45° angle away from the exterior wall.

502.2.1.5 Crawl space walls. If the floor above a crawl space does not meet the requirements of section 502.2.1.3 and the crawl space does not have ventilation openings that communicate directly with outside air, then the exterior walls of the crawl space shall have a thermal transmittance value not exceeding the value given in table 502.1a. Where the inside ground surface is less than 0.305 m (12 in.) below the outside finish ground level or the vertical wall insulation stops less than 0.305 m (12 in.) below the outside finish ground level, crawl space wall insulation shall extend vertically and horizontally a minimum total distance of 0.610 m (24 in.) linearly from the outside finish ground level (see RS–13).

502.2.1.6 Basement walls. The exterior walls of basements below uninsulated floors shall have a thermal transmittance value not exceeding the value given in table 502.1a from the top of the basement wall to a depth of 3.05 m (10 ft) below the outside finish ground level, or to the level of the basement floor, whichever is less.

502.2.2 Compliance by whole building performance. The stated U_O, U, or R value of an assembly may be increased or decreased, provided the total heat gain or loss for the entire building does not exceed the total resulting from conformance to the values specified in table 502.1a.

502.3 Air leakage.

502.3.1 Window and door assemblies. Window and door assemblies installed in the building envelope shall comply with the maximum infiltration rates allowed in RS–15, –16, –17, –18, and –19.

502.3.1.1 Exception. Site-constructed windows and doors shall be sealed in accordance with section 502.3.2.

502.3.2 Caulking and sealants. Joints, openings, and penetrations in the building envelope that are sources of air leakage shall be sealed with caulking, gasketing, weather-stripping, house wrap, or other materials compatible with the construction materials, location, and anticipated conditions. Sealants used in joints between dissimilar materials shall allow for differential expansion and contraction of such materials.

502.3.3 Recessed lighting fixtures. When installed in the building envelope, recessed lighting fixtures shall meet one of the following requirements:

(a) Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and the ceiling cavity, and sealed or gasketed to prevent air leakage into the unconditioned space.

(b) Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 0.013-m (½-in.) thick gypsum wallboard, a preformed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose. The fixture shall maintain a 0.013-m (½-in.) minimum clearance from combustible material and 0.064 m (3 in.) minimum clearance from insulation material.

(c) Type IC rated in accordance with RS–15 with no more than 0.944 L/s (2.0 cfm) air movement from the conditioned space to the ceiling cavity. The fixture shall be tested at 75 Pascals or 1.57 psf pressure differential and shall be labeled.

§ 435.503 Building mechanical systems and equipment.

503.1 General. This section covers mechanical systems and equipment used to provide heating, ventilating, and air-conditioning functions.

503.2 Mechanical equipment efficiency. Mechanical equipment used to provide heating and air-conditioning functions shall be selected pursuant to the following:

503.2.1 Detached one and two family dwellings. Heating and air-conditioning equipment selection shall comply with section 503.2.1.1 or section 503.2.1.2.

503.2.1.1 Minimum federal standards. The installed equipment type shall have the lowest life-cycle cost of all the applicable equipment included in table 503.2, when those equipment types have been evaluated at the minimum equipment performance efficiency allowed under Federal standards as specified in 10 CFR part 430.

503.2.1.2 Alternative approach. Any equipment that is at least as life-cycle cost-effective as the equipment identified in section 503.2.1.1 may be installed.

503.2.1.3 When either the selected equipment or the equipment identified in table 503.2 to which it is compared provides both heating and cooling, the life-cycle cost comparison shall be based on the combined life-cycle cost of providing heating and cooling services. Otherwise, separate heating and cooling life-cycle cost comparisons shall be made.

503.2.1.4 All such equipment shall be installed in accordance with the manufacturer's instructions.

TABLE 503.2.—MECHANICAL EQUIPMENT REGULATED BY FEDERAL LAW

Heat pump[1] or air conditioner; air, water or evaporatively cooled	<70,320 kW (<240,000 Btu/h)
Packaged Terminal Air Conditioner or Heat Pump.	All Capacities.
Warm Air Furnaces, Gas and Oil-Fired.	All Capacities.
Boilers, Gas-and Oil-Fired.	All Capacities.

[1] Does not include ground-water source heat pumps.

503.2.2 Central heating and air-conditioning units for multiple dwelling units in multi-family low rise dwellings. Heating and air-conditioning equipment selection shall comply with section 503.2.2.1 or section 503.2.2.2.

503.2.2.1 Equipment covered by RS–20. The installed equipment type shall have the lowest life-cycle cost of all the applicable equipment included in table 403.1 of RS–20, when those equipment types have been evaluated at the minimum equipment performance efficiency allowed by table 403.1 of RS–20 for the capacity required.

503.2.2.2 Alternative approach. Any equipment that is at least as life-cycle cost-effective as the equipment identified in section 503.2.2.1 may be installed.

503.2.2.3 When either the selected equipment or the equipment identified in table 403.1 of RS–20 to which it is compared provides both heating and cooling, the life-cycle cost comparison shall be based on the combined life-cycle cost of providing heating and cooling services. Otherwise, separate heating and cooling life-cycle cost comparisons shall be made.

503.2.2.4 All such equipment shall be installed in accordance with the manufacturer's instructions.

503.3 HVAC systems.

503.3.1 Load calculations. Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with the procedures described in RS–4, or an equivalent computation procedure, using the design parameters specified in section 302 of this part. Design loads shall account for infiltration.

503.3.1.1 Heating and cooling equipment capacity.

503.3.1.2 Heating equipment. The capacity of the equipment shall not exceed 170% of the design load.

503.3.1.3 Exception. Power burner and induced-draft burner fossil fuel heating equipment.

503.3.2 Cooling-only equipment. Equipment capable of providing only cooling shall be selected so the sensible capacity of the equipment is not less than the calculated total sensible cooling load but not more than 125% of the design sensible load or the closest available size provided by the manufacturer. The corresponding latent capacity of the equipment shall not be less than the calculated latent load.

503.3.3 Heat pump equipment. Heat pump sizing shall be based on the cooling design requirements and shall not exceed 125% of the cooling load at design conditions. For variable-speed or multiple-speed units, the cooling capacity at the lowest speed shall not exceed 125% of the cooling load at design conditions. Alternatively, where these data are not available for design temperatures, the capacity at the design heating temperature may be determined by interpolation or extrapolation of manufacturers' performance data. The auxiliary electric resistance heat capacity shall not exceed 120% of the design heating requirement.

503.3.4 Central electric furnace. Central electric furnaces shall be installed within the conditioned space unless they are specifically designed for use outside the conditioned space. Such furnaces greater than 12 kW (3.42 tons) shall be divided into at least two stages. An electric heat pump or an off-peak electric heating system with thermal storage shall be installed in conjunction with the furnace for locations with 111 HDD, base 18.3 °C (200 HDD, base 65 °F) or more.

503.4 Temperature and humidity controls.

503.4.1 System controls. Each dwelling unit shall be considered a zone and be provided with thermostatic controls responding to temperature within the dwelling unit. Each heating and cooling system shall include at least one temperature control device. Where a dwelling unit is served by more than one system, the thermostatic controls of each system shall prevent simultaneous operation in different modes.

503.4.2 Thermostatic control capabilities. Where used to control comfort heating, thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors down to 12.9 °C (55 °F) or lower.

503.4.2.1 Where used to control comfort cooling, thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors up to 29.4 °C (85 °F) or higher.

503.4.2.2 Where used to control both comfort heating and cooling, thermostatic controls shall be capable of providing a temperature range or deadband of up to 5.6 °C (10 °F) or more within which the supply of heating and cooling energy is shut off or reduced to a minimum.

503.4.2.2.1 Exception. Thermostats that require manual changeover between heating and cooling modes.

503.4.3 Heat pump supplementary heater. The heat pump shall be installed with controls to prevent supplementary heater operation when the operating load can be met by the heat pump alone. Supplementary heater operation is permitted during transient periods, such as start-ups, following room thermostat set-point advance, and during defrost.

503.4.4 Humidistat. Humidistats used for comfort purposes shall be capable of being set to prevent the use of fossil fuel or electricity to reduce relative humidity below 60% when reducing moisture or to increase relative humidity above 30% when adding moisture.

503.5 Distribution system construction and insulation.

503.5.1 Piping insulation. All HVAC system piping shall be thermally insulated in accordance with table 503.5.1a.

503.5.1.1 Exceptions.

(a) Factory-installed piping within HVAC equipment tested and rated in accordance with section 503.2.

(b) Piping that conveys fluids which have a design operating temperature range between 12.8 °C (55 °F) and 48.9 °C (120 °F).

(c) When the heat loss and/or heat gain of the piping without insulation does not increase the energy requirement of the building.

(d) When the piping is installed in basements, cellars, or unventilated crawl spaces having insulated walls.

(e) When additional insulation or vapor barriers have been specified to prevent condensation.

TABLE 503.5.1A.—MINIMUM PIPE INSULATION [THICKNESS IN METERS (INCHES)] [3]

Piping system types	Fluid temperature range, °C (°F)	Pipe sizes [2]					
		Run outs 0.051 m (2 in.)[1]	0.025 m (1 in.) and less	0.032 to 0.051 m (1.25 to 2 in.)	0.064 to 0.102 m (2.5 to 4 in.)	0.127 to 0.152 m (5 to 6 in.)	0.203 m (8 in.) and larger
Heating Systems Steam and Hot Water							
High pressure/ temperature.	152.2–232.2	0.038	0.064	0.064	0.076	0.089	0.089
	(306–450)	(1.5)	(2.5)	(2.5)	(3)	(3.5)	(3.5)
Medium pressure/ temperature.	121.7–151.7	0.038	0.051	0.064	0.064	0.076	0.076
	(251–305)	(1.5)	(2)	(2.5)	(2.5)	(3)	(3)
Low pressure/ temperature.	93.9–121.1	0.025	0.038	0.038	0.051	0.051	0.051
	(201–250)	(1)	(1.5)	(1.5)	(2)	(2)	(2)
Low temperature	48.9–93.3	0.013	0.025	0.025	0.038	0.038	0.038

TABLE 503.5.1A.—MINIMUM PIPE INSULATION [THICKNESS IN METERS (INCHES)] [3]—Continued

Piping system types	Fluid temperature range, °C (°F)	Pipe sizes [2]					
		Run outs 0.051 m (2 in.)[1]	0.025 m (1 in.) and less	0.032 to 0.051 m (1.25 to 2 in.)	0.064 to 0.102 m (2.5 to 4 in.)	0.127 to 0.152 m (5 to 6 in.)	0.203 m (8 in.) and larger
	(120–200)	(0.5)	(1)	(1)	(1.5)	(1.5)	(1.5)
Steam condensate (for feed water).	Any	0.025	0.025	0.038	0.051	0.051	0.051
		(1)	(1)	(1.5)	(2)	(2)	(2)
Cooling Systems							
Chilled water	4.4–12.8	0.013	0.013	0.019	0.025	0.025	0.025
	(40–55)	(0.5)	(0.5)	(0.75)	(1)	(1)	(1)
Refrigerant, or brine	Below 4.4	0.025	0.025	0.038	0.038	0.038	0.038
	(40)	(1)	(1)	(1.5)	(1.5)	(1.5)	(1.5)

[1] Runouts not exceeding 3.66 m (12 ft) in length to individual terminal units.
[2] For piping exposed to outdoor air, increase insulation thickness by 0.0127 m (0.5 in.).
[3] Insulation thicknesses are based on insulation having thermal resistivity in the range of 27.7 to 31.9 (m^2.°C)/W per meter [4.0 to 4.6 h.ft^2.°F/Btu per inch] of thickness on a flat surface at a mean temperature of 23.9°C (75°F).

503.5.1.2 For materials with thermal resistivity greater than 0.81 (4.6), the minimum insulation thickness may be reduced as determined by equation 503.5.1.2a:

$$\frac{0.81\ (4.6) \times \text{Table 503.3.3.1 Thickness}}{\text{Actual Resistivity}} = \text{New Minimum Thickness} \quad \text{(Equation 503.5.1.2a)}$$

503.5.1.3 For materials with thermal resistivity less than 0.71 (4.0), the minimum insulation thickness shall be increased as determined by equation 503.5.1.2b:

$$\frac{0.71\ (4.0) \times \text{Table 503.5.1a Thickness}}{\text{Actual Resistivity}} = \text{New Minimum Thickness} \quad \text{(Equation 503.5.1.2b)}$$

503.5.2 [RESERVED]

503.5.3 [RESERVED]

503.5.4 [RESERVED]

503.5.5 [RESERVED]

503.5.6 Duct system insulation. All supply and return air ducts and plenums installed as part of an HVAC air distribution system shall be insulated to provide a thermal resistance, excluding film resistances, to that value determined by equation 503.5.6a:

$$R = \frac{\Delta t}{47.3} m^2 \cdot K/W = \frac{\Delta t}{15} h \cdot ft^2 \cdot {}^\circ F/Btu \quad \text{(Equation 503.5.6a)}$$

Where Δ t= the design temperature difference between the air in the duct and the temperature of the ambient air in contact with the exterior duct surface.

503.5.6.1 Exceptions. Duct insulation, except as required to prevent condensation, is not required in the following cases:

(a) When Δ t is 13.9 °C (25 °F) or less.

(b) When supply-or return-air ducts are installed in basements, cellars, or unventilated crawl spaces having insulated walls in one-and two-family dwellings.

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

(d) Within HVAC equipment.

(e) Exhaust air ducts.

503.5.6.2 For buildings with uninsulated roofs over attics containing ducts, the air temperature shown in table 503.5.6.2 shall be used.

TABLE 503.5.6.2.—ATTIC TEMPERATURES

Seasonal conditions	Temperature
Summer conditions:	
Roof slope:	
5 in 12 and up ...	54.4 °C (130 °F).
3 in 12 to 5 in 12	60.0 °C (140 °F).
less than 3 in 12	65.6 °C (150 °F).
Winter conditions all slopes.	5.56 °C (10 °F) above outdoor design.

503.5.7 Duct construction. Ductwork shall be constructed and erected in accordance with Standards RS–6, RS–21, RS–22, RS–23, or RS–24 listed in section 801 of this part or in accordance with the construction documents.

503.5.7.1 Duct testing. High-pressure and medium-pressure ducts shall be leak tested in accordance with the applicable standards in section 801 of this part with the rate of air leakage not to exceed the maximum rate specified in that standard.

503.5.7.2 Duct sealing. All low-pressure supply and return air ducts, including those that are created within stud bays or joist cavities by covering with sheet metal, shall be sealed using mastic with fibrous backing tape installed according to the manufacturer's specifications. Other sealants may be specified if their performance can be demonstrated to equal or exceed that of mastic with fibrous backing tape. For fibrous glass ductwork, pressure-sensitive tape may be used if installed in accordance with RS–24. Duct tape is not permitted as a sealant on any ducts.

503.5.8 Mechanical ventilation. Each mechanical ventilation system (supply and/or exhaust) shall be equipped with a readily accessible switch or other means for shutoff or volume reduction and shutoff when ventilation is not required. Automatic or gravity dampers that close when the system is not operating shall be provided for outdoor air intakes and exhausts.

503.5.9 Combustion air. Each combustion device shall be properly installed and provided with a sufficient air supply to meet the air flow requirements for that device. For any fuel-burning equipment installed in the dwelling unit, combustion zone depressurization shall not exceed the equipment's depressurization limit.

503.5.9.1 Backdrafting test. Dwelling units that have installed combustion appliances requiring a vent pipe or chimney (including gas clothes dryers, water heaters, furnaces, fireplaces, and wood stoves) shall be tested for depressurization-induced chimney failure (backdrafting) in accordance with RS–25. If backdrafting occurs, the cause of insufficient make-up air shall be identified and corrected before occupancy. Testing is not required if the combustion air is supplied directly from the outdoors to the combustion chamber via a sealed passageway, and the products of combustion are exhausted directly outdoors through an independent sealed vent.

503.5.9.2 Combustion air supplies. Any duct, pipe, screened opening or other construction feature which serves to provide combustion air to fossil-fuel burning appliances, including service water heaters, shall be prominently labeled in a readily accessible location directly on or immediately adjacent to the construction feature. The label shall contain the following statement, or words conveying a similar intent:

Warning: This pipe [duct, vent, etc.] has been installed to provide combustion air for an appliance that burns natural gas, propane gas, fuel oil, or any solid fuel. It should not be modified or obstructed in any way, without first consulting a qualified HVAC contractor or your local building department. Obstruction or improper modification may cause toxic combustion products to be drawn into the living space of the home.

503.5.10 Transport energy. The air transport factor for each all-air system shall be not less than 5.5 when calculated in accordance with equation 503.5.10a. The factor shall be based on design system air flow. Energy for transfer of air through heat recovery devices shall not be included in determining the factor.

$$\text{Air Transport Factor} = \frac{\text{Space Sensible Heat Load Removal Rate}^{1}}{\text{Supply} + \text{Return Fan(s) Power Input}^{1}} \quad \text{(Equation 503.5.10a)}$$

[1] Expressed in watts (Btu/h).

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

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

503.5.11 Balancing. The HVAC system design shall provide means for balancing air and water systems. Components for balancing include dampers, temperature and pressure test connections, and balancing valves.

§ 435.504 Service water heating.

504.1 General. 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. Water supplies to ice-making machines and refrigerators shall be taken from a cold-water line of the water distribution system.

504.2 Performance efficiency. Mechanical equipment used to provide residential service water heating functions shall be selected pursuant to the following:

504.2.1 Detached one and two family dwellings. Service water heating equipment selection shall comply with section 504.2.1.1 or section 504.2.1.2.

504.2.1.1 Minimum federal standards. The installed equipment type shall have the lowest life-cycle cost of all the applicable equipment included in section 430.32(d) of 10 CFR part 430, Subpart C, when those equipment types have been evaluated at the minimum equipment performance efficiency allowed under Federal standards as specified in 10 CFR part 430.

504.2.1.2 Alternative approach. Any equipment that is at least as life-cycle cost-effective as the equipment identified in section 504.2.1.1 may be installed.

504.2.1.3 When either the selected equipment or the equipment identified in section 403.32(d) of 10 CFR part 430, Subpart C to which it is compared provides heating or cooling to the conditioned space of the building, in addition to service water heating, the life-cycle cost comparison shall be based on the combined life-cycle cost of providing service water heating and the heating or cooling service. Otherwise, separate life-cycle cost comparisons shall be made.

504.2.1.4 All such equipment shall be installed in accordance with the manufacturer's instructions.

504.2.2 Service water heating units for multiple dwelling units in multi-family low rise dwellings. Service water heating equipment selection shall comply with section 504.2.2.1 or section 504.2.2.2.

504.2.2.1 Equipment covered by RS–20. The installed equipment type shall have the lowest life-cycle cost of all the applicable equipment included in table 404.1 of RS–20, when those equipment types have been evaluated at the minimum equipment performance efficiency allowed by table 404.1 of RS–20.

504.2.2.2 Alternative approach. Any equipment that is at least as life-cycle cost-effective as the equipment identified in section 504.2.2.1 may be installed.

504.2.2.3 When either the selected equipment or the equipment identified in table 404.1 of RS–20 to which it is compared provides heating or cooling to the conditioned space of the building, in addition to service water heating, the life-cycle cost comparison shall be based on the combined life-cycle cost of providing service water heating and heating or cooling service. Otherwise, separate life-cycle cost comparisons shall be made.

504.2.2.4 All such equipment shall be installed in accordance with the manufacturer's instructions.

504.3 Combination service water heating and space heating equipment. Equipment shall not be used to serve both space heating and service water heating unless: the annual space heating energy is less than 50% of the annual service water heating energy; the energy input or storage volume of the combined space heating equipment and water heater is less than twice the energy input or storage volume of the smaller of the separate space heating equipment or water heaters otherwise required; or the input to the combined equipment is less than 43.95 kW (150,000 Btu/h).

504.4 Heat traps. Water heaters with vertical pipe risers shall have a heat trap installed on both the inlet and outlet of the water heater unless the water heater has an integral heat trap or is part of a circulating system.

504.5 Automatic controls. Service water-heating systems shall be equipped with automatic temperature controls capable of maintaining a pre-selected temperature. The control shall be preselected to a temperature of 60 °C (140 °F) or less.

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

504.7 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 heater is not in operation.

504.8 Pipe insulation. For recirculating systems, piping heat loss shall be limited to a maximum of 5.13 W (17.5 Btu/h) per linear foot of pipe by insulating in accordance with table 504.8a. Table 504.8a is based on a design temperature external to the system piping of 18.3 °C (65 °F) minimum. Lower design temperatures shall require recalculation of the required piping insulation to limit heat loss to the above amount.

504.8.1 Exception. Piping insulation is not required when the heat loss of the piping, without insulation, does not increase the annual energy requirements of the building.

TABLE 504.8a.—MINIMUM PIPE INSULATION [2]

[Thickness in meters (inches)]

Service water heating temperatures °C (°F)	Pipe sizes [1]			
	Noncirculating runouts	Circulating mains and runouts		
	Up to 0.025 m (1 in.)	Up to 0.032 m (1.25 in.)	0.038–0.051 m (1.5–2 in.)	Over 0.051 m (2 in.)
76.7–82.2 (170–180)	0.013 (0.5)	0.025 (1.0)	0.038 (1.5)	0.051 (2.0)
60.0–71.1 (140–160)	0.013 (0.5)	0.013 (0.5)	0.025 (1.0)	0.038 (1.5)
37.8–54.4 (100–130)	0.013 (0.5)	0.013 (0.5)	0.013 (0.5)	0.025 (1.0)

[1] Nominal iron pipe size and insulation thickness.
[2] See footnote 3 from table 503.5.1a.

§ 435.505 Electrical power and lighting.

505.1 Electrical energy consumption. Each separate dwelling unit of multifamily residential buildings shall be individually metered.

505.1.1 Exception. Transient facilities such as dormitories and bachelors' quarters are exempt from the requirements of section 505.1.

505.2 Lighting power budget. The lighting system of the non-dwelling portion of multi-family residences, such as common stairwells and corridors, shall meet the applicable lighting provisions of RS–20.

Subpart F—[Reserved]

Subpart G—Radon Control

§ 435.701 General.

This subpart provides minimum requirements for the control of radon from the ground and from construction materials associated with buildings. This subpart does not provide requirements for the control of radon from ground water or drinking water.

§ 435.702 Scope.

702.1 Building types. These radon control provisions apply to new Federal residential buildings, additions to the foundations of such buildings, and renovations to such buildings where the foundation wall will be exposed.

702.1.2 Exception. Three story multifamily residential buildings that have dwelling units only on the third floor are exempt from the requirements of this subpart.

702.2 Building locations. This subpart applies to any new construction located completely or partially in Zone 1 on the U.S. Map of Radon Zones as specified in Appendix table 702.2. This subpart shall also apply when locally available data, or a radon potential map derived from non-local data, indicate a particular site may have a radon potential commensurate with that in Zone 1, although not listed in Appendix table 702.2 as being in Zone 1.

702.2.1 Exception. Where measured data collected at or near to the proposed construction site, or a radon potential map derived from non-local data, indicate the construction site does not have a radon potential commensurate with that in Zone 1, the provisions of this subpart shall not apply.

§ 435.703 Compliance.

703.1 General. Buildings located in areas classified as Zone 1 as defined in section 702.2 shall comply with the design and construction requirements provided in section 707.

703.2 Long-term testing. Starting within 30 days after occupancy, the building shall be tested for an integration period no less than six months in accordance with RS–26. If the radon level is at or above 4 pCi/L, the radon ventilation system shall be activated in accordance with RS–27 within one month of the completion of testing.

703.3 Short-term testing. Short-term testing shall be performed and concluded within 30 days of occupancy for an integration period no less than 7 days in accordance with RS–26. If the radon level is at or above 20 pCi/L, a second short-term test shall be performed for a minimum of 7 days beginning at the conclusion of the first short-term test. If the average of the two tests exceeds 20 pCi/L, the radon ventilation system shall be activated.

703.4 Follow-up testing.

703.4.1 Radon testing; short-term. If the ventilation system has been activated in response to long-term or short-term testing, additional radon testing shall be completed within 10 days of system activation for a minimum integration period of two days. If the test results exceed 4 pCi/L, additional radon mitigation measures shall be performed. After mitigation, any further testing shall be performed.

703.4.2 Radon testing; long-term. If the results of short-term testing performed under section 703.4.1 are 4 pCi/L or less, the long-term testing required under section 703.2 shall be re-initiated upon conclusion of the short-term test for an integration period no less than 6 months. If the test results exceed 4 pCi/l, additional radon mitigation shall be performed. After mitigation, any further testing shall be performed.

703.4.3 Backdrafting testing. If the ventilation system has been activated in response to long-term or short-term testing, additional backdrafting testing shall be performed, in accordance with the provisions of section 503.5.9.1, within 30 days of system activation.

703.5 Reporting of test results. All radon test results shall be reported to the Deputy Assistant Secretary for Building Technologies (EE–40) at the U.S. Department of Energy, Washington, DC 20585.

703.6 Ventilation fan alarm. If the radon ventilation fan has been activated in response to testing under this section, a visual indication of fan operation, or an alarm indicating fan failure, shall be installed within the living space of the dwelling unit.

§ 435.704 Alternative systems.

The requirements of this subpart are not intended to preempt, preclude, or restrict the application or use of alternative materials, systems, or construction practices. Alternative materials, systems, or methods of construction shall be acceptable when they can be shown to yield radon control equivalent to that required herein. To be considered equivalent, a radon level below 4 pCi/L shall be demonstrated through long-term testing conducted on a similar building (design with similar environmental conditions and operational schedules) located in the same radon potential zone, using the proposed alternative approaches. Any alternative system is still subject to the testing and reporting requirements of section 703.

§ 435.705 Conflict with other standards, codes, or regulations.

The provisions of this subpart are not intended to conflict with other health and safety provisions of any other applicable standards, codes, or regulations. When a conflict occurs, the requirement with the greater positive impact on the health and safety of the building occupants shall prevail.

§ 435.706 Qualification of testers and installers.

Active radon control systems shall be designed and installed by individuals who are state-certified as radon mitigation contractors or by an individual listed in the EPA Radon Contractor Proficiency Program. All radon testing shall be performed or supervised by individuals who are state-certified as radon measurement contractors or are listed in the EPA Radon Contractor Proficiency Program.

§ 435.707 Design and construction requirements.

707.1 Slab-on-grade foundations and slab-below-grade floor assemblies.

707.1.1 Subfloor preparation. A 0.089 m (4-in.) thick layer of clean graded sand overlain by a continuous layer or strips of geotextile drainage matting designed to allow the lateral flow of soil gas, or clean aggregate passing through a 0.051-m (2-in.) sieve and retained on a 6.4 mm (¼-in.) sieve, shall be placed under all concrete slabs and other floor systems (such as treated-wood floors on ground) that directly contact the ground and are within the walls of the living spaces of the building.

707.1.2 Sub-slab membrane.

707.1.2.1 Application. A 6-mil (or 3-mil cross-laminated) polyethylene or equivalent flexible sheeting material shall be placed on top of the subfloor prior to casting the slab or placing the floor assembly. The sheeting shall cover the entire floor area with separate sections of sheeting overlapped at least 0.305 m (12 in.). The sheeting shall extend to within 13 mm (½ in.) of all pipes, wires, or other penetrations of the material.

707.1.2.2 Sealing. All seams, lap joints, penetrations, punctures, tears, and other disturbances of the continuity of the sub-slab membrane shall be sealed with mastic or tape compatible with the membrane material. Paper or cloth tape shall not be used. Where additional pieces of membrane material are used for sealing, the piece shall overlap the discontinuity a minimum of 12 inches on all sides and shall be sealed with mastic or tape.

707.1.3 Concrete floor slabs. Concrete floor slabs shall be designed, mixed, placed, reinforced, consolidated, finished, and cured in accordance with RS–28.

707.1.3.1 Stakes. The use of grade or support stakes which penetrate the subslab membrane shall be avoided. Permanent and/or temporary concrete blocks or screed chairs may be used. Where stakes are used to support plumbing pipes, electrical conduits, or other objects which penetrate the slab, they shall be sealed to the slab in accordance with section 707.1.4. These stakes shall be solid or have the upper end sealed tightly by installation of an end cap designed to provide a gas-tight seal. Support stakes shall be of non-porous material resistant to decay, corrosion and rust.

707.1.4 Sealing of floor slabs.

707.1.4.1 Openings. Openings through concrete slabs, wood, or other floor assemblies which provide a direct path to exposed soil (such as spaces around bathtub, shower, or toilet drains) shall be filled or closed with non-shrink mortar, grout, expanding foam, polyurethane caulk, elastomeric sealant, or other similar material designed for such application that adheres to the surrounding material and remains flexible. Where large work spaces are formed into a slab, such as beneath a bath tub drain, the exposed soil shall be fully covered with a solvent-based plastic roof cement or other material, to a minimum depth of 1 inch.

707.1.4.2 Penetrations. Gaps around pipe, wire, or other objects that penetrate concrete slabs, wood, or other floor assemblies shall be made airtight with an elastomeric joint sealant as defined in RS–29 and applied in accordance with RS–30 and the sealant manufacturer's installation instructions.

707.1.4.3 Joints. All control joints, isolation joints, construction joints, and other joints in concrete slabs or between slabs and foundation walls shall be sealed. A continuous formed gap (for example, a ''tooled edge''), which allows for the application of a sealant that will provide a continuous, airtight seal, shall be created along all joints. When the slab has cured, the gap shall be cleared of loose material and filled with an elastomeric joint sealant as described in section 707.1.4.2.

707.1.4.4 Cracks. Cracks in the field of a slab with widths greater than 1.59 mm (1⁄16 in.) shall be routed to a recess with minimum dimensions of 6.35 mm (¼ in.) by 6.35 mm (¼ in.) and sealed with an approved sealant.

707.1.5 Foundation walls.

707.1.5.1 Concrete and masonry. Below-grade concrete and masonry foundation walls shall be water-proofed. Where basements are constructed with hollow block masonry, the exterior walls shall be covered with 6-mil minimum polyethylene sheeting, extending from the finished grade to cover the joint with the footing. Hollow block masonry walls shall be constructed with one continuous course of solid masonry, masonry that is grouted solid, or a solid concrete beam; the continuous course shall be located at or above finished grade. Where a brick veneer or other masonry ledge is installed, the course immediately below that ledge shall be sealed in the same manner.

707.1.5.2 Wood. Pressure-treated wood foundations shall be constructed, installed, and water-proofed in accordance with RS–31.

707.1.5.3 Joints and penetrations. Joints, cracks, or other openings around all below-grade penetrations or wall ties shall be sealed airtight with an elastomeric sealant on both the inside and outside surfaces of the foundation wall.

707.2 Crawl spaces.

707.2.1 Openings. Openings around all penetrations of those building assemblies that separate crawl spaces from habitable space shall be sealed to prevent air leakage. Means of egress and ingress between habitable spaces and crawl spaces, such as hatches or access doors, shall be sealed or gasketed to prevent air leakage.

707.2.2 Ventilation. Crawl spaces shall be provided with at least 0.0929 m^2 (1 ft^2) net free area of ventilation openings for each 27.9 m^2 (300 ft^2) of crawl space area. Such vents shall be through the exterior wall and be of noncloseable design.

707.2.3 Ground cover. The soil in crawl spaces shall be cleaned of all vegetation and organic matter and covered with a continuous layer of 6-mil thick polyethylene sheeting or an equivalent membrane material. The sheeting shall be lapped at least 0.305 m (12 in.) at joints. All seams, joints, penetrations, punctures, and tears in the ground cover membrane shall be sealed in accordance with section 707.1.2.2. The membrane shall fully cover the floor and abut to the foundation walls or footings.

707.3 Vent system.

707.3.1 Passive sub-membrane depressurization system for crawl space construction. One continuous, uninterrupted vent pipe, sealed permanently gas-tight at joints, at least 0.064 m (3 in.) in diameter, and meeting the provisions of RS–32 or RS–33 shall be provided to vent the soil in the crawl space. The vent pipe shall be connected to a plumbing ''T'' fitting and inserted between the membrane and the soil such that the ''T'' fitting rests on the ground and its openings are completely below the membrane. A minimum of five feet of perforated drain pipe of three inches minimum diameter shall join to and extend from each opening of the ''T.'' The pipe perforations shall be parallel to the plane of the ground and shall not be capped at the ends. The ''T'' and its perforated extensions shall be located at least 1.52 m (5 ft) and no more than 5.49 m (18 ft) (measured in a horizontal plane) from the exterior perimeter of the crawlspace area. The vent pipe shall terminate above the roof as required in section 707.3.4. The vent pipe shall have a maximum of 3 elbow or tee fittings between the sub-membrane fitting and the roof termination.

707.3.2 Passive sub-slab depressurization system for basement floor and slab-on-grade foundation construction. A minimum of one continuous, uninterrupted vent pipe, sealed permanently gas-tight at joints, at least 0.64 m (3 in.) in diameter, and meeting the provisions of RS–32 or RS–33 shall be provided to vent the soil below the floor slab. The vent pipe shall have a plumbing ''T'' fitting of the same diameter at one end that shall be placed into the subslab aggregate or other permeable material before the slab is poured. The ''T'' fitting openings shall be completely below the sub-slab membrane. Each subslab termination of the vent pipe shall serve no more than 232 m^2 (2500 ft^2) of slab floor area. The ''T'' fittings shall be located at least five feet and no more than 5.49 m (18 ft) (measured in a horizontal plane) from the exterior perimeter of the foundation. The pipe shall terminate above the roof as required in section 707.3.4. The vent pipe shall have a maximum of 3 elbow or tee fittings between the sub-slab fitting and the roof termination.

707.3.2.1 Multiple suction points. Where a single residence has multiple floor slabs, floor slabs in excess of 232 m^2 (2500 ft^2), or floor slabs that are provided and separated by interior footings or other barriers to the lateral flow of subslab soil gas, additional vent pipes shall be installed to ensure that all subslab areas are ventilated. Such pipes shall run independently and terminate as required in section 707.3.4 or shall be manifolded in an accessible location and connected to a single vent terminating above the roof as required in section 707.3.4. Each vent pipe, even if manifolded, shall have a maximum of 3 elbow or tee fittings between the sub-slab fitting and the corresponding roof termination.

707.3.2.2 Exceptions. A sealed slab sump exposed to the sub-slab aggregate, or internal drain tile loops that are stubbed up through the slab, either of which is in turn connected to a vent pipe extending vertically and terminating above the roof as required in section 707.3.4, are exempt from the requirements of section 707.3.2.

707.3.3 Combination construction. In combination basement/crawl space or slab-on-grade/crawl space construction, the vent systems required by sections 707.3.1 or 707.3.2 shall be separate systems or manifolded in an accessible location and connected to a single vent terminating above the roof as required in section 707.3.4.

707.3.4 Vent pipe termination. The vent pipe shall run through the conditioned part of the house to the greatest extent possible and shall not be located within an external wall. A portion of the vent pipe shall be accessible in the attic or other area outside of the habitable space. The vent pipe shall be labeled ''RADON REDUCTION SYSTEM'' in 0.051-m (2-in.) high black letters on a yellow band on each floor level where the vent pipe(s) is exposed and visible. The vent pipe shall be installed with a minimum slope of 3.18 mm (⅛-in.) per 0.305 m (ft) to drain rainwater or condensate by gravity to the soil. The vent pipe shall terminate in a vertical section that extends at least 0.305 m (12 in.) above the surface of the roof. The termination point shall be at least 3.05 m (10 ft) away from any window or other opening into the building's conditioned space that is less than 0.610 m (2 ft) below the termination point. The termination point shall be at least 3.05 m (10 ft) from any adjoining or adjacent buildings.

707.3.5 Electrical service. An approved electrical junction box rated for a 20 amp feed to an external device shall be installed within 20 feet of that portion of the vent pipe in the attic or other area outside of the habitable space identified in section 707.3.4.

707.4 Plumbing system interconnections.

707.4.1 Drains. Floor drains shall be trapped and connected to the building's sanitary drain system. Condensate drains serving cooling coils shall terminate outside the building to daylight or to a floor drain, plumbing fixture, sump, or other approved location.

707.4.2 Sumps. Sumps open to soil or serving as the termination point for subslab or exterior drain tile loops shall be tightly covered. When serving as a floor drain, the sump lid shall be equipped with a trapped inlet.

707.5 HVAC system interconnections.

707.5.1 Air-handling units. Air-handling units shall not be located in crawl spaces or other areas exposed to soil gas.

707.5.1.1 Exception. When the air-handler is sealed so as to preclude the circulation of air from the area exposed to soil gas.

707.5.2 Ducts. Air-handling ducts exposed to soil gas shall be made permanently airtight by sealing in accordance with section 503.5.7. Ducts shall not be installed beneath slabs.

707.5.3 Plenums. Air circulation plenums shall not be located in crawl spaces or in other construction assemblies directly exposed to soil gas. Any plenum assembly shall be made permanently airtight by sealing in accordance with section 503.5.7.

Subpart H—Standards

§ 435.801 Reference standards.

801.1 The standards, and portions thereof, which are referred to in various sections, paragraphs, and subparagraphs of this part shall be considered a part of this part.

Code standard No.	Title and source
RS–1	National Fenestration Rating Council 100–91, Procedure for Determining Fenestration Product Thermal Properties, National Fenestration Rating Council, 1300 Spring St., Suite 120, Silver Spring, MD 20910.
RS–2	ANSI/ASHRAE 55–1992, Thermal Environmental Conditions for Human Occupancy, American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. 1791 Tullie Circle, N.E., Atlanta, GA 30329–2305.
RS–3	ANSI/ASHRAE Standard 62–1989, Ventilation for Acceptable Indoor Air Quality, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 1791 Tullie Circle, N.E., Atlanta, GA 30329–2305.
RS–4	1993 ASHRAE Handbook of Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 3 0329–2305.
RS–5	ASTM E 779–87, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–6	1992 ASHRAE HVAC Systems and Equipment Handbook, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329–2305.
RS–7	ASHRAE, Energy Calculations I: Procedures for Determining Heating and Cooling Loads for Computerizing Energy Calculations, Algorithms for Building Heat Transfer Subsystems, 1975, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329–2305.
RS–8	BuilderGuide Energy Analysis Software for Homebuilders, Passive Solar Industries Council, Passive Solar Industries Council, 1511 K. Street N.W., Suite 600, Washington, DC 20005.
RS–9	ASTM C 177–85, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–10	ASTM C 518–91, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–11	ASTM C 236–89, Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded-Hot-Box, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–12	ASTM C 976–90, Standard Test Method for Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–13	1988 Builder's Foundation Handbook. U.S. Department of Energy, Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge TN 37831–9939.
RS–14	ASTM E 96–94, Standard Test Methods for Water Vapor Transmission of Materials, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–15	ASTM E 283–91, Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–16	ANSI/NWWDA I.S.2–87, Industry Standard for Wood Window Units, National Wood Window and Door Association, 1400 Touhy Ave., Des Plaines, IL 60018.
RS–17	ANSI/AAMA 101–93, Voluntary Specifications for Aluminum and Poly (Vinyl Chloride) (PVC) Prime Windows and Glass Doors, American Architectural Manufacturers Association, Des Plaines, IL 60018.
RS–18	ASTM D 4099–93, Standard Specification for PVC Prime Windows/Sliding Glass Doors, American Society for Testing and Materials 1916 Race Street, Philadelphia, PA 19103.
RS–19	NWWDA I.S.3–88, Industry Standard for Wood Sliding Patio Doors, National Wood Window and Door Association, 1400 Touhy Ave., Des Plaines, IL 60018.
RS–20	Energy Code for Commercial and High-Rise Residential Buildings—Codification of ASHRAE/IESNA 90.1–1989, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329–2305.
RS–21	SMACNA, Installation Standards for Residential Heating and Air Conditioning Systems, Sixth Edition, 1988, Sheet Metal and Air Conditioning Contractors Nat'l Assoc., 4201 Lafayette Center, Dr., Chantilly, VA 22021–1209.
RS–22	SMACNA, HVAC Duct Construction Standards—Metal and Flexible, First Edition, 1985, Sheet Metal and Air Conditioning Contractors Nat'l Assoc., 4201 Lafayette Center, Dr., Chantilly, VA 22021–1209.
RS–23	SMACNA Fibrous Glass Duct Construction Standards, 6th Edition, Washington, D.C., 1992, Sheet Metal and Air Conditioning Contractors Nat'l Assoc. 4201 Lafayette Center, Dr., Chantilly, VA 22021–1209.
RS–24	NAIMA Fibrous Glass Duct Construction Standards, 1989 Edition, North American Insulation Manufacturers Assoc., 44 Canal Center Plaza, Suite 310, Alexandria, VA 22314.
RS–25	CGSB, The Spillage Test. CAN/CGSB–51.71–94, Canadian General Standards Board, 222 Queen Street, Suite 1402, Ottawa, Ontario, Canada K1A 1G6.
RS–26	EPA 402–R–92–003, Protocol for Radon & Radon Decay Product Measurements in Homes, United States Environmental Protection Agency, Washington, DC 20460.
RS–27	EPA 402–R–93–078, Radon Mitigation Standards, United States Environmental Protection Agency, Washington, DC 20460.
RS–28	ACI Standard 302.1R–89, Guide for Concrete Floor and Slab Construction, American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, MI 48219.

Code standard No.	Title and source
RS–29	ASTM C 920–94, Standard Specification for Elastomeric Joint Sealant, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–30	ASTM C 1193–91, Standard Guide for Use of Joint Sealants, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–31	Permanent Wood Foundation Design and Construction Guide, Southern Pine Council, Southern Pine Council, P.O. Box 641700, Kenner, LA 70064.
RS–32	ASTM D 2665–94, Standard Specification for PVC Plastic Drain, Waste, and Vent Pipe and Fittings, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–33	ASTM D 2661–94A, Standard Specification for ABS Plastic Drain, waste, and Vent Pipe and Fittings, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
RS–34	Analysis of Options for EPA's Model Standards for Controlling Radon in New Homes, United States Environmental Protection Agency, Washington, DC 20460.

§ 435.802 Abbreviations and acronyms used in reference standards.

AAMA American Architectural Manufacturers Association

ACI American Concrete Institute

ACCA Air Conditioning Contractors of America

ANSI American National Standards Institute, Inc.

ARI Air Conditioning and Refrigeration Institute

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

ASTM American Society for Testing and Materials

CABO Council of American Building Officials

CGSB Canadian General Standards Board

OSTI U.S. Department of Energy

EPA United States Environmental Protection Agency

NWWDA National Wood Window and Door Association

NAIMA North American Insulation Manufacturers Assoc.

NFRC National Fenestration Ratings Council

PSIC Passive Solar Industries Council

SMACNA Sheet Metal and Air Conditioning Contractors Nat'l Assoc.

SPC Southern Pine Council

BILLING CODE 6450–01–P

Appendix to Part 435—Figures and Tables

Figure 1. Maximum U_o-value for Walls

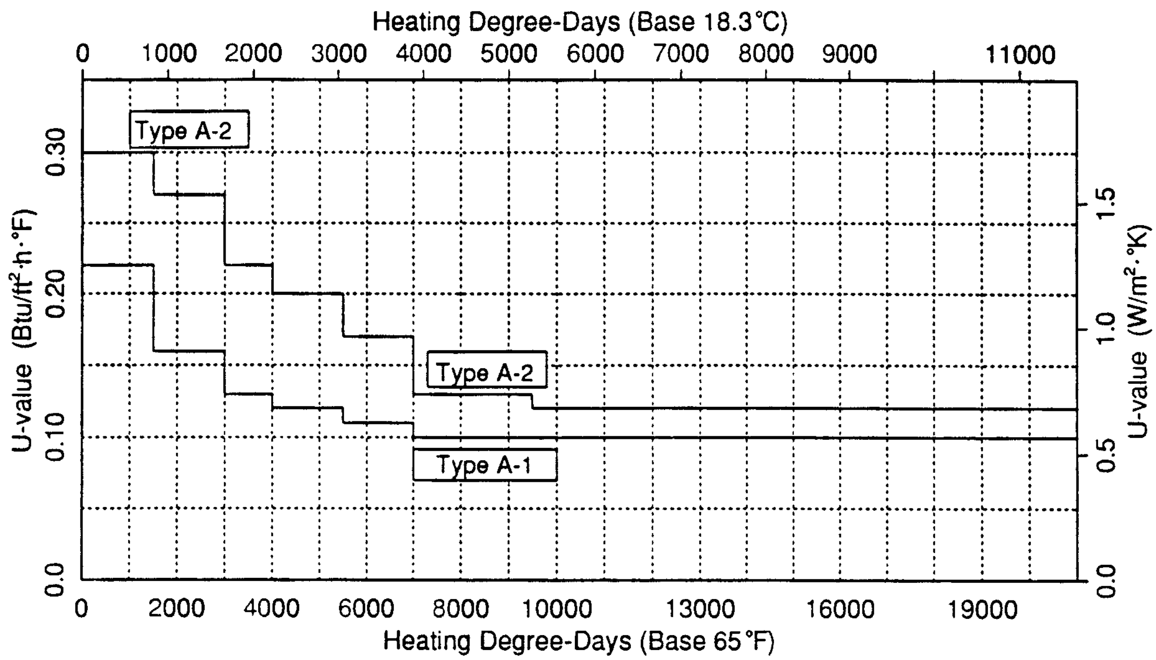

Figure 2. Maximum U_o-value for Roof/Ceilings

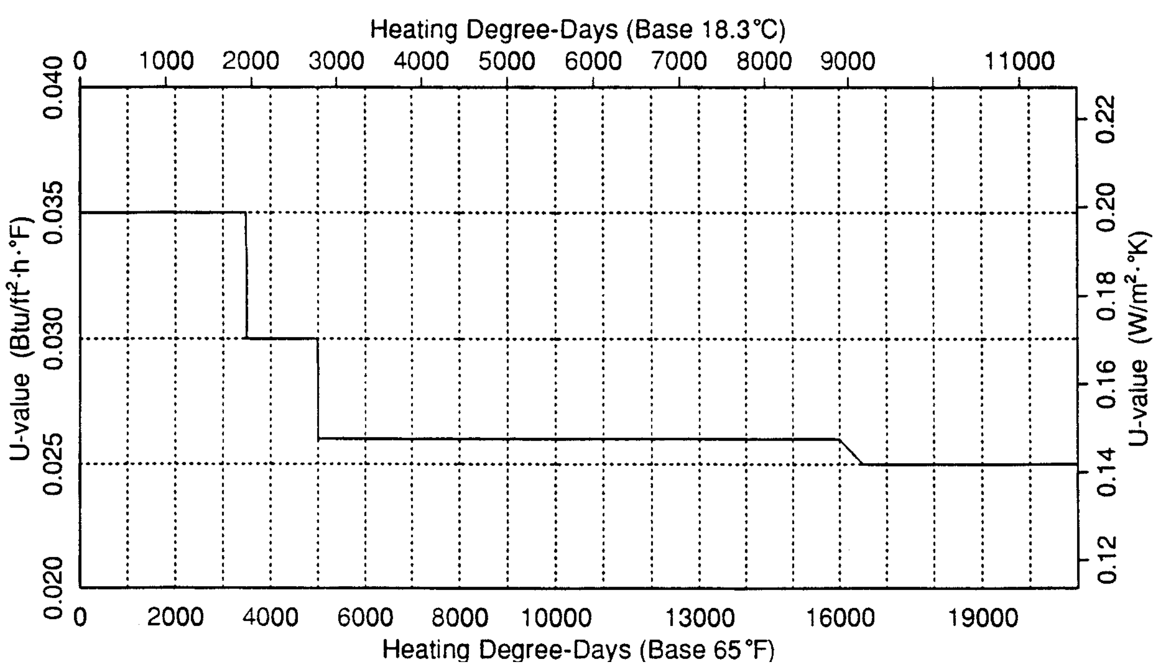

Figure 3. Minimum R-value and Insulation Depth for Slab-on-Grade

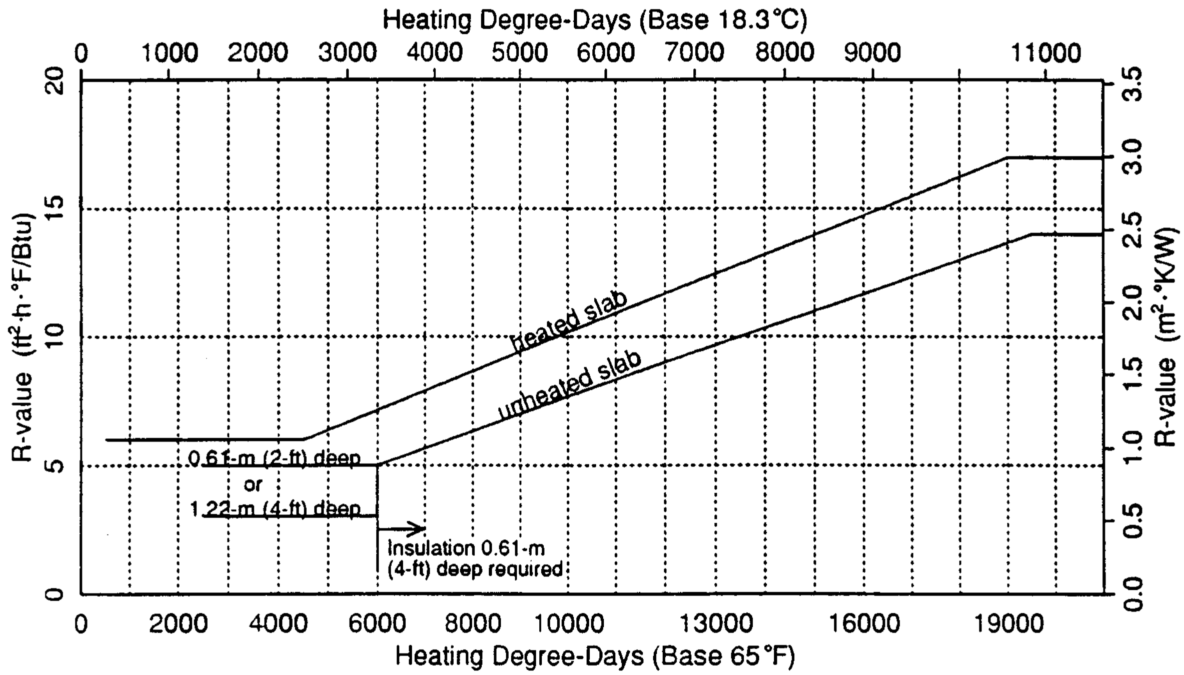

Figure 4. Maximum U_o-value for Floors Over Unheated Spaces

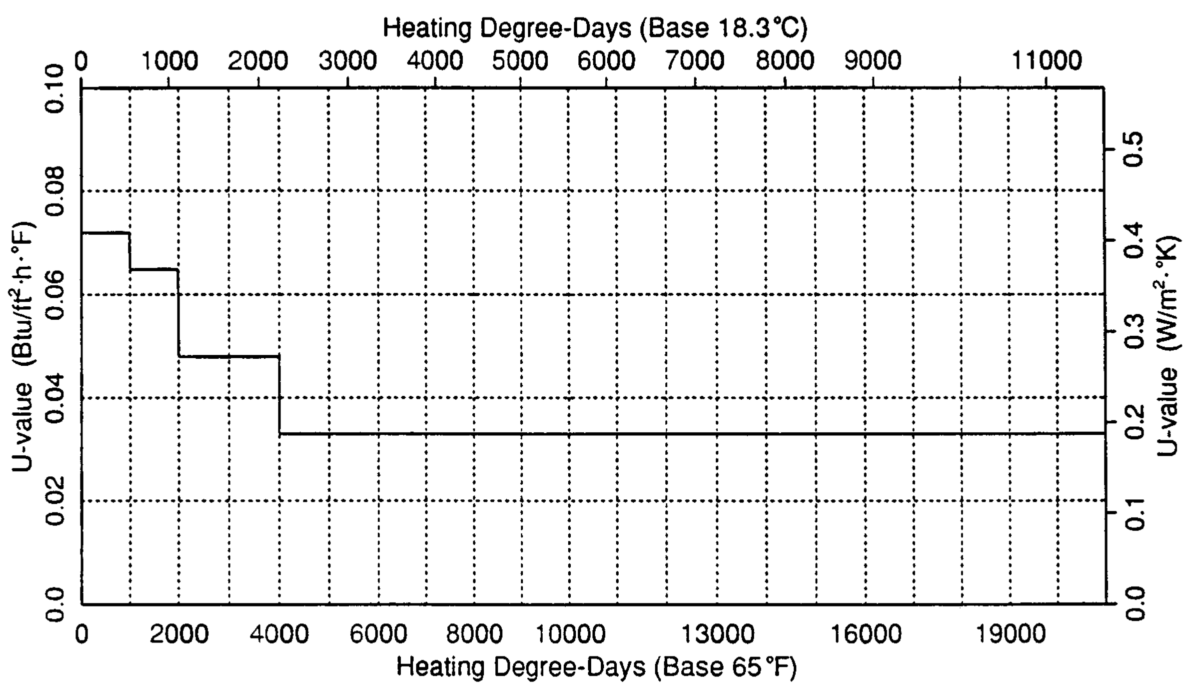

Figure 5. Maximum U_o-value for Crawl Space Walls

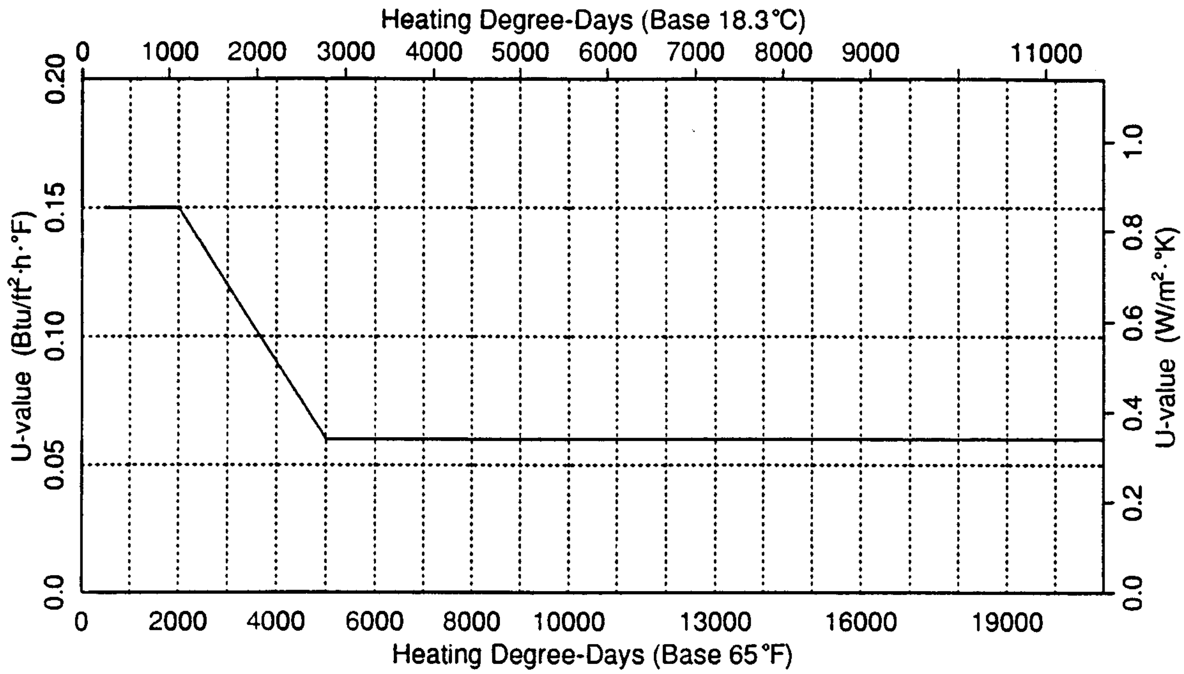

Figure 6. Maximum U_o-value for Basement Walls

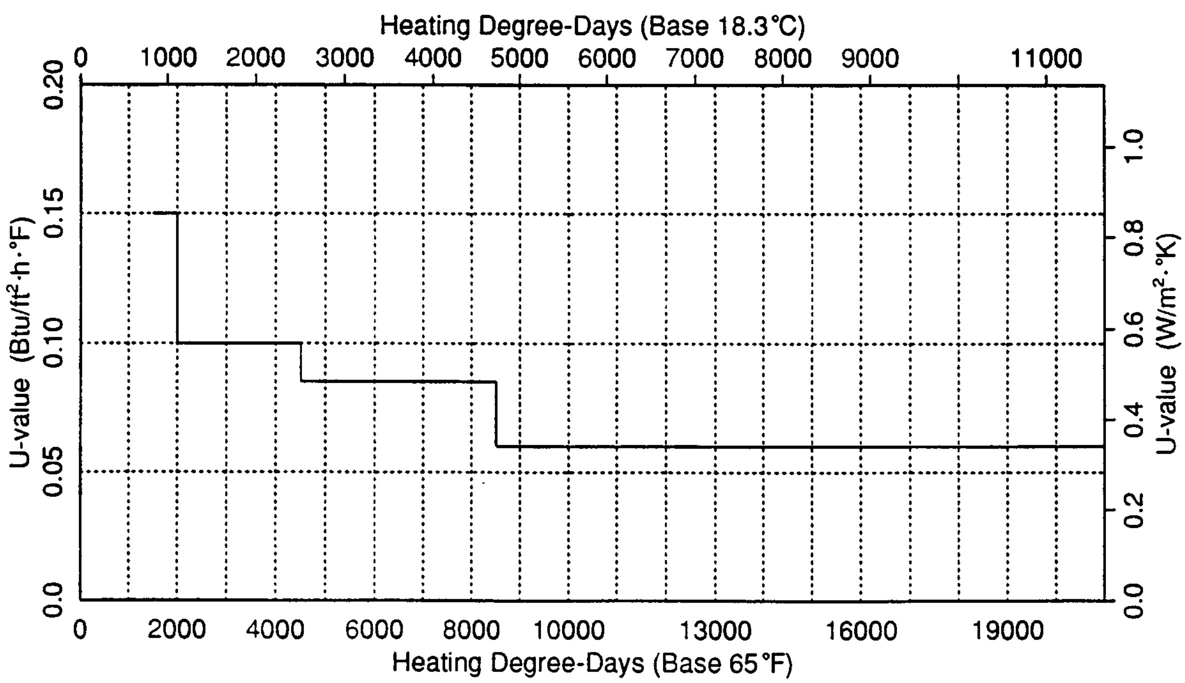

Table 102.3.1.

U-Value Default Table for Windows, Glazed Doors, and Skylights

	Single $W/m^2 \cdot °K$ ($Btu/h \cdot ft^2 \cdot °F$)	Double $W/m^2 \cdot °K$ ($Btu/h \cdot ft^2 \cdot °F$)
Metal Without Thermal		
Break	7.38 (1.30)	4.94 (.87)
Operable	6.64 (1.17)	3.92 (.69)
Fixed	7.15 (1.26)	4.54 (.80)
Door	10.90 (1.92)	7.38 (1.30)
Skylight		
Metal With Thermal Break		
Operable	6.08 (1.07)	3.80 (.67)
Fixed	6.30 (1.11)	3.58 (.63)
Door	6.25 (1.10)	3.75 (.66)
Skylight	10.96 (1.93)	6.42 (1.13)
Metal-Clad Wood		
Operable	5.56 (.98)	3.41 (.60)
Fixed	5.96 (1.05)	3.29 (.58)
Door	5.62 (.99)	3.24 (.57)
Skylight	8.52 (1.50)	5.00 (.88)
Wood/Vinyl		
Operable	5.34 (.94)	3.18 (.56)
Fixed	5.91 (1.04)	3.24 (.57)
Door	5.56 (.98)	3.18 (.56)
Skylight	8.35 (1.47)	4.83 (.85)

Table 102.3.2.

U-Value Default Table for Nonglazed Doors

	$W/m^2 \cdot °K$ ($Btu/h \cdot ft^2 \cdot °F$)	
Steel Doors	With Foam Core 1.99 (0.35)	Without Foam Core 3.41 (0.60)
	Without Storm	With Storm
Wood Doors [4.44 cm (1.75 in.) Thick]	3.07 (0.54)	2.04 (0.36)
Panel with 1.11 cm (7/16-in.) Panels	2.61 (0.46)	1.82 (0.32)
Hollowcore Flush	2.21 (0.39)	1.59 (0.28)
Panel with 2.86 cm (1 1/8-in.) Panels	2.27 (0.40)	1.48 (0.26)
Solid Core Flush		

Table 502.2.1.1.2.

Correction Factors for Wall Sections with Metal Studs

Size of Members	Stud Gage	Spacing of Framing	R_{ins} $m^2 \cdot °K/W$ ($h \cdot ft^2 \cdot °F/Btu$)	F_c
0.038 X 0.089 m (2 x 4 in.)	18 - 16	0.406 m O.C. (16 in.)	1.94 (R-11) 2.29 (R-13) 2.64 (R-15)	0.50 0.46 0.43
0.038 X 0.089 m (2 x 4 in.)	18 - 16	0.610 m O.C. (24 in.)	1.94 (R-11) 2.29 (R-13) 2.64 (R-15)	0.60 0.55 0.52
0.038 X 0.152 m (2 x 6 in.)	18 - 16	0.406 m O.C. (16 in.)	3.35 (R-19) 3.70 (R-21)	0.37 0.35
0.038 X 0.152 m (2 x 6 in.)	18 - 16	0.610 m O.C. (24 in.)	3.35 (R-19) 3.70 (R-21)	0.45 0.43
0.038 X 0.203 m (2 x 8 in.)	18 - 16	0.406 m O.C. (16 in.)	4.40 (R-25)	0.31
0.038 X 0.203 m (2 x 8 in.)	18 - 16	0.610 m O.C. (24 in.)	4.40 (R-25)	0.38
Note: F_c factors also apply to metal studs thinner than 18 gage.				

Table 702.2

Table 702.2 shall be used to determine the scope of the radon control provisions as covered in Section 702.2. Only EPA-designated Zone 1 counties are listed.

ALABAMA
Calhoun
Clay
Cleburne
Colbert
Coosa
Franklin
Jackson
Lauderdale
Lawrence
Limestone
Madison
Morgan
Talladega

CALIFORNIA
Santa Barbara
Ventura

COLORADO
Adams
Arapahoe
Baca
Bent
Boulder
Chaffee
Cheyenne
Clear Creek
Crowley
Custer
Delta
Denver
Dolores
Douglas
Elbert
El Paso
Fremont
Garfield
Gilpin
Grand
Gunnison
Huerfano
Jackson
Jefferson
Kiowa
Kit Carson
Lake
Larimer
Las Animas
Lincoln
Logan
Mesa
Moffat
Montezuma
Montrose
Morgan
Otero
Ouray
Park
Phillips
Pitkin
Prowers
Pueblo
Rio Blanco
San Miguel
Sedgwick
Summit
Teller
Washington
Weld
Yuma

CONNECTICUT
Fairfield
Middlesex
New Haven
New London

GEORGIA
Cobb
De Kalb
Fulton
Gwinnett

IDAHO
Benewah
Blaine
Boise
Bonner
Boundary
Butte
Camas
Clark
Clearwater
Custer
Elmore
Fremont
Gooding
Idaho
Kootenai
Latah
Lemhi
Shoshone
Valley

ILLINOIS
Adams
Boone
Brown
Bureau
Calhoun
Carroll
Cass
Champaign
Coles
De Kalb
De Witt
Douglas
Edgar
Ford
Fulton
Greene
Grundy
Hancock
Henderson
Henry
Iroquois
Jersey
Jo Daviess
Kane
Kendall
Knox
La Salle
Lee
Livingston
Logan
Mcdonough
Mclean
Macon
Marshall Mason
Menard
Mercer
Morgan
Moultrie
Ogle
Peoria
Piatt
Pike
Putnam
Rock Island
Sangamon
Schuyler
Scott
Stark
Stephenson
Tazewell

Vermilion
Warren
Whiteside
Winnebago
Woodford

INDIANA
Adams
Allen
Bartholomew
Benton
Blackford
Boone
Carroll
Cass
Clark
Clinton
Decatur
De Kalb
Delaware
Elkhart
Fayette
Fountain
Fulton
Grant
Hamilton
Hancock
Harrison
Hendricks
Henry
Howard
Huntington
Jay
Jennings
Johnson
Kosciusko
Lagrange
Lawrence
Madison
Marion
Marshall
Miami
Monroe
Montgomery
Noble
Orange
Putnam
Randolph
Rush
St Joseph
Scott
Shelby
Steuben
Tippecanoe
Tipton
Union
Vermillion
Wabash
Warren
Washington
Wayne
Wells
White
Whitley

IOWA
Adair
Adams
Allamakee
Appanoose
Audubon
Benton
Black Hawk
Boone
Bremer
Buchanan
Buena Vista
Butler
Calhoun
Carroll
Cass
Cedar
Cerro Gordo
Cherokee
Chickasaw
Clarke
Clay
Clayton
Clinton
Crawford
Dallas
Davis
Decatur
Delaware
Des Moines
Dickinson
Dubuque
Emmet
Fayette
Floyd
Franklin
Fremont
Greene
Grundy
Guthrie
Hamilton
Hancock
Hardin
Harrison
Henry
Howard
Humboldt
Ida
Iowa
Jackson
Jasper
Jefferson
Johnson
Jones
Keokuk
Kossuth
Lee
Linn
Louisa
Lucas
Lyon
Madison
Mahaska
Marion
Marshall
Mills
Mitchell
Monona
Monroe
Montgomery
Muscatine
Obrien
Osceola
Page
Palo Alto
Plymouth
Pocahontas
Polk Pottawattamie
Poweshiek
Ringgold
Sac
Scott
Shelby
Sioux
Story
Tama
Taylor
Union
Van Buren
Wapello
Warren
Washington
Wayne
Webster
Winnebago
Winneshiek
Woodbury
Worth
Wright

KANSAS
Atchison
Barton
Brown
Cheyenne
Clay
Cloud
Decatur
Dickinson
Douglas
Ellis

Ellsworth
Finney
Ford
Geary
Gove
Graham
Grant
Gray
Greeley
Hamilton
Haskell
Hodgeman
Jackson
Jewell
Johnson
Kearny
Kingman
Kiowa
Lane
Leavenworth
Lincoln
Logan
Mcpherson
Marion
Marshall
Meade
Mitchell
Nemaha
Ness
Norton
Osborne
Ottawa
Pawnee
Phillips
Pottawatomie
Pratt
Rawlins
Republic
Rice
Riley
Rooks
Rush
Russell
Saline
Scott
Sheridan
Sherman
Smith
Stanton
Thomas
Trego
Wallace
Washington
Wichita
Wyandotte

KENTUCKY
Adair
Allen
Barren
Bourbon
Boyle
Bullitt
Casey
Clark
Cumberland
Fayette
Franklin
Green
Harrison
Hart
Jefferson
Jessamine
Lincoln
Marion
Mercer
Metcalfe
Monroe
Nelson
Pendleton
Pulaski
Robertson
Russell
Scott
Taylor
Warren
Woodford

MAINE
Androscoggin
Aroostook
Cumberland
Franklin
Hancock
Kennebec
Lincoln
Oxford
Penobscot
Piscataquis
Somerset
York

MARYLAND
Baltimore
Calvert
Carroll
Frederick
Harford
Howard
Montgomery
Washington

MASSACHUSETTS
Essex
Middlesex
Worcester

MICHIGAN
Branch
Calhoun
Cass
Hillsdale
Jackson
Kalamazoo
Lenawee
St Joseph
Washtenaw

MINNESOTA
Becker
Big Stone
Blue Earth
Brown
Carver
Chippewa
Clay
Cottonwood
Dakota
Dodge
Douglas
Faribault
Fillmore
Freeborn
Goodhue
Grant
Hennepin
Houston
Hubbard
Jackson
Kanabec
Kandiyohi
Kittson
Lac Gui Parle
Le Sueur
Lincoln
Lyon
Mcleod
Mahnomen
Marshall
Martin
Meeker
Mower
Murray
Nicollet
Nobles
Norman
Olmsted
Otter Tail
Pennington
Pipestone
Polk
Pope
Ramsey
Red Lake
Redwood
Renville

Rice
Rock
Roseau
Scott
Sherburne
Sibley
Stearns
Steele
Stevens
Swift
Todd
Traverse
Wabasha
Wadena
Waseca
Washington
Watonwan
Wilkin
Winona
Wright
Yellow Medicine

MISSOURI
Andrew
Atchison
Buchanan
Cass
Clay
Clinton
Holt
Iron
Jackson
Nodaway
Platte

MONTANA
Beaverhead
Big Horn
Blaine
Broadwater
Carbon
Carter
Cascade
Chouteau
Custer
Daniels
Dawson
Deer Lodge
Fallon
Fergus
Flathead
Gallatin
Garfield
Glacier
Granite
Hill
Jefferson
Judith Basin
Lake
Lewis And Clark
Liberty
Lincoln
Mccone
Madison
Meagher
Mineral
Missoula
Park
Phillips
Pondera
Powder River
Powell
Prairie
Ravalli
Richland
Roosevelt
Rosebud
Sanders
Sheridan
Silver Bow
Stillwater
Teton
Toole
Valley
Wibaux
Yellowstone
National Park

NEBRASKA
Adams
Boone
Boyd
Burt
Butler
Cass
Cedar
Clay
Colfax
Cuming
Dakota
Dixon
Dodge
Douglas
Fillmore
Franklin
Frontier
Furnas
Gage
Gosper
Greeley Hamilton
Harlan
Hayes
Hitchcock
Jefferson
Johnson
Kearney
Knox
Lancaster
Madison
Nance
Nemaha
Nuckolls
Otoe
Pawnee
Phelps
Pierce
Platte
Polk
Red Willow
Richardson
Saline
Sarpy
Saunders
Seward
Stanton
Thayer
Thurston
Washington
Wayne
Webster
York

NEVADA
Carson City
Douglas
Eureka
Lander
Lincoln
Lyon
Mineral
Pershing
White Pine

NEW HAMPSHIRE
Carroll

NEW JERSEY
Hunterdon
Mercer
Monmouth
Morris
Somerset
Sussex
Warren

NEW MEXICO
Bernalillo
Colfax
Mora
Rio Arriba
San Miguel
Santa Fe
Taos

NEW YORK
Albany

Allegany
Broome
Cattaraugus
Cayuga
Chautauqua
Chemung
Chenango
Columbia
Cortland
Delaware
Dutchess
Erie
Genesee
Greene
Livingston
Madison
Onondaga
Ontario
Orange
Otsego
Putnam
Rensselaer
Schoharie
Schuyler
Seneca
Steuben
Sullivan
Tioga
Tompkins
Ulster
Washington
Wyoming
Yates

NORTH CAROLINA
Alleghany
Buncombe
Cherokee
Henderson
Mitchell
Rockingham
Transylvania
Watauga

NORTH DAKOTA
Adams
Barnes
Benson
Billings
Bottineau
Bowman
Burke
Burleigh
Cass
Cavalier
Dickey
Divide
Dunn
Eddy
Emmons
Foster
Golden Valley
Grand Forks
Grant
Griggs
Hettinger
Kidder
La Moure
Logan
Mchenry
Mcintosh
Mckenzie
Mclean
Mercer
Morton
Mountrail
Nelson
Oliver
Pembina
Pierce
Ramsey
Ransom
Renville
Richland
Rolette
Sargent
Sheridan
Sioux
Slope
Stark
Steele
Stutsman Towner
Traill
Walsh
Ward
Wells
Williams

OHIO
Adams
Allen
Ashland
Auglaize
Belmont
Butler
Carroll
Champaign
Clark
Clinton
Columbiana
Coshocton
Crawford
Darke
Delaware
Fairfield
Fayette
Franklin
Greene
Guernsey
Hamilton
Hancock
Hardin
Harrison
Holmes
Huron
Jefferson
Knox
Licking
Logan
Madison
Marion
Mercer
Miami
Montgomery
Morrow
Muskingum
Perry
Pickaway
Pike
Preble
Richland
Ross
Seneca
Shelby
Stark
Summit
Tuscarawas
Union
Van Wert
Warren
Wayne
Wyandot

PENNSYLVANIA
Adams
Allegheny
Armstrong
Beaver
Bedford
Berks
Blair
Bradford
Bucks
Butler
Cameron
Carbon
Centre
Chester
Clarion
Clearfield
Clinton
Columbia
Cumberland
Dauphin
Delaware
Franklin

Fulton
Huntingdon
Indiana
Juniata
Lackawanna
Lancaster
Lebanon
Lehigh
Luzerne
Lycoming
Mifflin
Monroe
Montgomery
Montour
Northampton
Northumberland
Perry
Schuylkill
Snyder
Sullivan
Susquehanna
Tioga
Union
Venango
Westmoreland
Wyoming
York

RHODE ISLAND
Kent
Washington

SOUTH CAROLINA
Greenville

SOUTH DAKOTA
Aurora
Beadle
Bon Homme
Brookings
Brown
Brule
Buffalo
Campbell
Charles Mix
Clark
Clay
Codington
Corson
Davison
Day
Deuel
Douglas
Edmunds
Faulk
Grant
Hamlin
Hand
Hanson
Hughes
Hutchinson
Hyde
Jerauld
Kingsbury
Lake
Lincoln
Lyman
Mccook
Mcpherson
Marshall
Miner
Minnehaha
Moody
Perkins
Potter Roberts
Sanborn
Spink
Stanley
Sully
Turner
Union
Walworth
Yankton

TENNESSEE
Anderson
Bedford
Blount
Bradley
Claiborne
Davidson
Giles
Grainger
Greene
Hamblen
Hancock
Hawkins
Hickman
Humphreys
Jackson
Jefferson
Knox
Lawrence
Lewis
Lincoln
Loudon
Mcminn
Marshall
Maury
Meigs
Monroe
Moore
Perry
Roane
Rutherford
Smith
Sullivan
Trousdale
Union
Washington
Wayne
Williamson
Wilson

UTAH
Carbon
Duchesne
Grand
Piute
Sanpete
Sevier
Uintah

VIRGINIA
Alleghany
Amelia
Appomattox
Augusta
Bath
Bland
Botetourt
Brunswick
Buckingham
Campbell
Chesterfield
Clarke
Craig
Cumberland
Dinwiddie
Fairfax
Fluvanna
Frederick
Giles
Goochland
Henry
Highland
Lee
Louisa
Montgomery
Nottoway
Orange
Page
Patrick
Pittsylvania
Powhatan
Pulaski
Roanoke
Rockbridge
Rockingham
Russell
Scott
Shenandoah
Smyth
Spotsylvania
Stafford

Tazewell
Warren
Washington
Wythe

WASHINGTON
Clark
Ferry
Okanogan
Pend Oreille
Skamania
Spokane
Stevens

WEST VIRGINIA
Berkeley
Brooke
Grant
Greenbrier
Hampshire
Hancock
Hardy
Jefferson
Marshall
Mercer
Mineral
Monongalia
Monroe
Morgan
Ohio
Pendleton
Pocahontas
Preston
Summers
Wetzel

WISCONSIN
Buffalo
Crawford
Dane
Dodge
Door
Fond Du Lac
Grant
Green
Green Lake
Iowa
Jefferson
Lafayette
Langlade
Marathon
Pepin
Pierce
Portage
Richland
Rock
St Croix
Shawano
Vernon Walworth
Washington
Waukesha
Waupaca
Wood

WYOMING
Albany
Big Horn
Campbell
Carbon
Converse
Crook
Fremont
Goshen
Hot Springs
Johnson
Laramie
Lincoln
Natrona
Niobrara
Park
Sheridan
Sublette
Sweetwater
Teton
Uinta
Washakie
Menominee

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