

**DEPARTMENT OF ENERGY****Office of Energy Efficiency and Renewable Energy****10 CFR Parts 434 and 435**

[Docket No. EE-RM-79-112-C]

RIN 1904-AA69

**Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings****AGENCY:** Office of Energy Efficiency and Renewable Energy, DOE.**ACTION:** Notice of proposed rulemaking and public hearing and request for public comment.

**SUMMARY:** The Department of Energy today proposes a rule that would establish building energy efficiency standards for new Federal commercial and multi-family high rise residential buildings pursuant to the requirements of the Energy Conservation and Production Act. The proposed rule would revise the current interim Federal standards to conform generally with the format of the current voluntary building energy codes. The proposed rule would incorporate changes from the interim rule in the areas of lighting, mechanical ventilation, motors, building envelopes, and fenestration rating procedures, and test procedures for heating and cooling equipment.

**DATES:** Written comments on the proposed rule (10 copies) must be received by the Department by 4 p.m. on or before November 4, 1996. A public hearing will be held on September 4, 1996, beginning at 9 a.m. at the address listed below. Requests to speak must be received by the Department by 4 p.m. on or before August 28, 1996. Ten copies of the statement to be given at the public hearing must be received by the Department by 4 p.m. August 29, 1996.

**ADDRESSES:** Address written comments, requests for copies of the technical support documents and oral statements, requests to speak at the hearing, and requests for speaker lists to: Energy Code for Federal Commercial Buildings, Docket No. EE-RM-79-112-C, Buildings Division, EE-431, Office of Codes and Standards, U.S. Department of Energy, Room 1J-018, 1000 Independence Avenue, SW., Washington, DC 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 SW., Washington, DC 20585-0121. Copies of the transcript of the public hearing and public comments received may be read

at the DOE Freedom of Information Reading Room, U.S. Department of Energy, Forrestal Building, Room 1E-190, 1000 Independence Avenue SW., Washington, DC 20585-0121, (202) 586-6020, between the hours of 9 a.m. and 4 p.m., except Federal holidays.

For more information concerning public participation see Section VIII, Public Comment Procedures.

**FOR FURTHER INFORMATION CONTACT:**

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**SUPPLEMENTARY INFORMATION:**

- I. Introduction
  - A. Authority
  - B. Background
- II. Description of the Proposed Rule
  - A. General
  - B. Format and Structure of the Proposed Rule
  - C. Comparison of the Proposed Rule with the Interim Standard
  - D. Comparison of Codified Version of Standard 90.1-1989 to the Proposed Rule and Comparison Between Standard 90.1-1989 Addenda and the Proposed Rule
  - E. Explanation of Differences between the Proposed Rule and the Statutory Baseline
- III. Consultation
- IV. Energy Impacts
- V. Technological Feasibility and Economic Justification
- VI. Measures Concerning Radon and Other Indoor Air Pollutants
- VII. Findings and Certification
  - A. Federalism Review
  - B. Review Under Executive Order on Promulgating Regulations 12988
  - C. Regulatory Planning and Review
  - D. Review Under the Regulatory Flexibility Act
  - E. Review Under the National Environmental Policy Act
  - F. Environmental Protection Agency Review
  - G. Paperwork Reduction Act Review
  - H. Unfunded Mandates Reform Act Review
  - I. Review Under Section 32 of the Federal Energy Administration Authorization Act
- VIII. Public Comment Procedures
  - A. Participation in Rulemaking
  - B. Written Comment Procedures
  - C. Public Hearing Procedures

**I. Introduction****A. Authority**

Section 305(a) of the Energy Conservation and Production Act

(ECPA), as amended, 42 U.S.C. 6834(a), requires DOE to establish by rule Federal building energy standards for new Federal buildings. In developing this proposed rule, DOE is directed to consult with other federal agencies as well as private and state associations and other appropriate persons.

The proposed rule must contain energy saving and renewable energy specifications that meet or exceed the energy saving and renewable energy specifications of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)/Illuminating Engineering Society of North America (IES) Standard 90.1-1989 (Standard 90.1-1989) for commercial buildings and of the Model Energy Code (MEC), 1992, for residential buildings. MEC 1992 exempts multi-family high-rise residential buildings (over three stories in height above ground) which comply with Standard 90.1-1989. As a result, Standard 90.1-1989 is the applicable standard under Section 305 of ECPA for high-rise residential buildings.

Section 305(a) requires that the standards contain energy efficiency measures that are technologically feasible and economically justified. Since ECPA, as amended, establishes that the new standards meet, at a minimum, the requirements of Standard 90.1-1989, technological feasibility and economic justification need not be established for these minimum requirements. DOE is interpreting this minimum requirement to include those addenda to Standard 90.1-1989 which were in effect at the time the Energy Policy Act of 1992 (EPACT), which amended ECPA, was enacted. Since these addenda were part of Standard 90.1-1989 at the time EPACT was enacted, they are part of the baseline against which the proposed rule is compared for purposes of assessing its energy and economic impacts.

Section 305(a)(2)(B) requires that to the extent practicable, the new federal building energy standards use the same format as the appropriate voluntary building energy code. The proposed rule would revise the current interim federal standards to conform generally with the format and language of the codified version of Standard 90.1-1989. The addenda to Standard 90.1-1989 included in the proposed rule are also generally incorporated in their codified form.

Section 305(a)(2)(c) further 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.

Section 305(c) states that the standards proposed in today's rule be reviewed and, if appropriate, updated at not less than five year intervals.

The standards proposed today are required to become effective no later than one year after the rule is issued. (See section 305(a)(1)). Section 305(d) continues in effect the interim energy performance standards (otherwise known as "interim rule" or "interim standards") for new Federal buildings as they existed before the date of the enactment in 1992 of EPACT until the standards established under subsection (a) become effective.

Section 306 addresses Federal compliance. Section 306(a) provides that 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(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*

On January 30, 1989, the Department issued an interim rule (10 CFR part 435, subpart A) establishing energy conservation voluntary performance standards for the design of new commercial and multi-family high rise residential buildings; these standards are mandatory for Federal buildings.

The Department's interim standards and Standard 90.1-1989 were developed in conjunction with one another and contain similar energy efficiency provisions. ASHRAE and IES are professional engineering societies which have undertaken the responsibility of sponsoring a voluntary industry consensus standard for the design of energy efficient commercial and multi-family high rise buildings.

The Department's interim rule and Standard 90.1-1989 followed a parallel development track. ASHRAE/IES provided technical expertise that ensured the practicality of the interim standards and Standard 90.1-1989. DOE contributed technical expertise and research results in the development of these two standards.

Because Standard 90.1-1989 is written as a standard of professional practice, it cannot be directly adopted as a building code. The Department in 1993 requested ASHRAE to assist DOE in producing a version of Standard 90.1-1989 and its addenda in code

format. This joint effort was undertaken to assist States in responding to Section 304(b) of ECPA and to assist DOE in establishing Federal building energy efficiency standards. The resulting code, published by ASHRAE/IES in November 1993 is entitled "Energy Code for Commercial and High-Rise Residential Buildings." This code has been approved by the Council of American Building Officials (CABO) as the basis for its MEC and some of the regional model codes.

Basing the proposed rule on the codified version of Standard 90.1-1989 ensures that the provisions of today's proposed rule would be similar to those being adopted by state and local jurisdictions and widely used in the private sector.

Moreover, ASHRAE/IES periodically modifies their current edition of their standard through an addenda process. Standard 90.1-1989 is the current edition of their standard. ASHRAE/IES has adopted six addenda to Standard 90.1-1989 since it was published in 1989. They are: Addenda b, c, d, e, g, and i. The proposed rule would include these addenda. These addenda are described below in II.D, Table 3. The proposed rule would also include provisions that are substantively the same as those in Addendum f, which has not been adopted by ASHRAE/IES.

DOE has chosen to publish the proposed rule in its entirety so that it is assembled in a unified form for easy access. DOE did not choose to merely publish changes from the codified version of Standard 90.1-1989 because of the integrated nature of the changes (small and large) from that codified version. The Department invites comments on whether Standard 90.1-1989, including appropriate addenda, should be incorporated Standard 90.1 by reference instead of publishing the rule in its entirety as DOE proposes today. If DOE were to incorporate Standard 90.1-1989 by reference, other proposed changes would need to be published as well.

## **II. Description of the Proposed Rule**

### *A. General*

The standards proposed today specify a minimum level of energy efficiency for new Federal commercial and high-rise residential buildings. The proposed rule would revise the current interim Federal standards to conform generally with the format and language of the codified version of Standard 90.1-1989. They do not address the design of residential single family or multi-family low rise buildings, currently addressed by Subpart C of 10 Part 435. Such buildings

will be addressed in a separate rulemaking.

The current interim standards for Federal commercial and multi-family high-rise residential buildings are found in Subpart A of 10 CFR Part 435. For clarity and ease of use, the Department is proposing to remove Subparts A and B of Part 435 and add a new Part 434, to contain the building energy efficiency standards for new Federal commercial and multi-family high-rise residential buildings.

Today's proposal contains substantive changes from the interim standard in the areas of lighting, mechanical ventilation, motors, building envelopes, fenestration rating procedures, and heating and cooling test procedures. It includes those addenda which were in effect at the time EPACT was enacted (Addendum 90.1b revising service water heating criteria and updating miscellaneous references to other standards, Addendum 90.1d addressing lighting controls, and Addendum 90.1e updating ventilation requirements).

The proposed rule also includes several addenda adopted by ASHRAE and IES after EPACT was enacted. These include Addenda g, i, and c, addressing building envelopes, heating and cooling equipment test procedures, and motor efficiency, respectively. DOE would also include provisions concerning procedures for calculating fenestration ratings. As previously mentioned, these provisions are substantively the same as Addendum f, now pending consideration by ASHRAE and IES.

The lighting standards in today's proposed rule would differ from both the interim standards and Standard 90.1-1989. The updated lighting provisions are more stringent than Standard 90.1-1989 and reflect new information concerning energy requirements needed to achieve adequate lighting levels.

The proposed rule would provide minimum standards of energy efficiency levels to be required in each new federal commercial and high-rise residential building. The individual specifications for lighting, HVAC, envelope, and other aspects of buildings found in subpart D of the proposed rule determine the minimum level of energy efficiency required for a particular building. This "prescriptive path" provides a simple means of ensuring design specifications that meet the proposed code.

Flexibility is a key feature of the proposed code. While some of the specific design requirements of subpart D apply in all cases, this proposed rule provides for flexibility in many other areas if building designers can show that the overall building energy use or

energy cost compares favorably to the baseline energy use or energy cost based on subpart D of the proposed rule. Tradeoffs among systems and among building shell components can be made using the DOE version of the Lighting Standard (LTGSTD) and Envelope Standard software (ENVSTD), respectively. Building-wide trade-offs among energy efficiency features or the inclusion of entirely new efficiency features, including passive and active renewable features, can be made as well. Subpart E allows building-wide flexibility as long as the net result equals or reduces energy costs. Subpart F allows these trades to be made if predicted total building energy use is below that expected using the "prescriptive path." These alternative paths are especially valuable as a means for building designers to take full advantage of the energy savings potential of new technologies. The computer software referenced above will be included as part of the Technical Support Document.

#### *B. Format and Structure of the Proposed Rule*

ASHRAE and IES have published Standard 90.1-1989 in a code format that does not differ in any significant technical or substantive respect from the standard itself. DOE has based the proposed rule on this codified version of Standard 90.1-1989, published by ASHRAE and IES in 1993, by adopting verbatim significant portions of it. Section II(E) of this notice discusses the substantive differences between the proposed rule and the statutory baseline.

The codified version is expected to be widely used by state and local code making bodies as they update their codes. The designers and builders of Federal buildings, who also design and construct State and private sector buildings, will be familiar with the requirements of the codified version, their importance, and how to meet them. Therefore, the consistency of the proposed rule with industry-wide

practices would facilitate implementation by federal agencies of the final rule.

Copies of the ASHRAE Energy Code and ASHRAE/IES Standard 90.1-1989 may be purchased from ASHRAE, 1791 Tullie Circle, NE., Atlanta, GA 30329 (1-800-5-ASHRAE).

#### *C. Comparison of the Proposed Rule With the Interim Standard*

The design and construction of new commercial and multi-family high-rise residential federal buildings is currently governed by interim energy efficiency standards issued in 1989. Table 1 provides a "cross-walk" from the elements of the current interim federal commercial and multi-family high-rise residential building standard to the proposed rule to facilitate a comparison between the two standards. Column 1 of the table lists all of the sections of the interim standard and column 2 lists the location of sections within the proposed rule which include or refer to the same topic.

TABLE 1.—SUBJECT CROSS-WALK BETWEEN THE CURRENT INTERIM FEDERAL COMMERCIAL AND MULTI-FAMILY HIGH RISE STANDARD AND THE PROPOSED FEDERAL RULE

Interim standards	Proposed rule
435.97 Purpose and 435.98 Scope .....	434.100 Administration and Enforcement.
435.99 General Definitions and Acronyms .....	434.200 Definitions.
435.100 Explanation of numbering systems for standards .....	434.99 Explanation of numbering systems for standards.
435.101 Implementation and compliance procedures for Federal agencies.	434.100 Administration and Enforcement—
435.102 Principles of effective energy building design .....	434.102 Compliance.
	Not included—Moved to Federal Users Manual, Performance standards for New Commercial and Multi-Family High Rise Residential Buildings. U.S. Department of Energy. March 1994.
435.103 Lighting .....	434.401.3 Lighting Systems and Equipment.
435.104 Auxiliary Systems and Equipment. ....	434.401.3 Lighting Systems & Equipment.
434.400 Building Design Requirements .....	434.403 Building Mechanical Systems and Equipment.
	434.404 Building Service Systems and Equipment.
435.105 Building Envelope .....	434.402 Building Envelope Assemblies & Materials.
434.300 Design Conditions .....	434.300 Design Conditions.
434.400 Building Design Requirements; 402 Building Envelope Assemblies & Materials.	434.402 Building Envelope Assemblies & Materials.
435.106 Electric Power and Distribution .....	434.401 Electric Systems and Equipment.
435.107 Heating Ventilation and Air-Conditioning (HVAC) Systems ....	434.403 Building Mechanical Systems and Equipment.
434.400 Building Design Requirements; 403 Building Mechanical Systems and Equipment.	434.403 Building Mechanical Systems and Equipment.
435.108 Heating ventilation and air-conditioning (HVAC) equipment ...	434.403 Building Mechanical Systems and Equipment.
435.109 Service water heating systems .....	434.404 Building Service Systems & Equipment.
434.400 Building Design Requirements .....	434.403 Building Mechanical Systems and Equipment.
435.110 Energy management .....	434.403 Building Service Systems and Equipment.
435.111 Building energy cost compliance alternative .....	434.102 Compliance.
	434.500 Building energy cost compliance alternative.
	434.102 Compliance.
	434.600 Building energy Compliance Alternative.
	434.700 Reference Standard.
435.112 Building energy compliance alternative .....	

*D. Comparison of Codified Version of Standard 90.1–1989 to the Proposed Rule and Comparison Between Standard 90.1–1989 Addenda and the Proposed Rule*

This section provides a “cross-walk” between the proposed rule and the

codified version of Standard 90.1–1989 as well as a “cross-walk” between the proposed rule and Standard 90.1–1989 Addenda. The codified version published November 1993, includes all of the addenda adopted by ASHRAE to date in their codified form. Addendum

f, dealing with fenestration, is pending consideration by ASHRAE. As a result, it is not included in the codified version of Standard 90.1–1989.

**Table 2.—SUBJECT CROSS WALK BETWEEN CODIFIED VERSION OF STANDARD 90.1–1989 AND THE PROPOSED FEDERAL RULE**

Codified 90.1–1989	Proposed rule
CHAPTER 1 ADMINISTRATION AND ENFORCEMENT .....	434.99 Explanation of Numbering System.
100 General .....	Subpart A—Administration and Enforcement—General
100.1 Title .....	
100.2 Purpose .....	434.100 Purpose.
101 Scope .....	434.101 Scope.
102 Compliance .....	434.102 Compliance.
103 Referenced Standards .....	434.103 Reference Standards.
104 Validity .....	434.104 Validity.
105 Materials .....	434.105 Materials and Equipment.
106 Plans and Specifications .....	434.106 Plans and Specifications.
107 Inspections .....	434.107 Inspections.
CHAPTER 2 DEFINITIONS .....	Subpart B—Definitions
201 Definitions .....	434.201 Definitions.
CHAPTER 3 DESIGN CONDITIONS .....	Subpart C—Design Conditions
301 Design Criteria .....	434.301 Design Criteria.
301.1 Exterior Design Conditions .....	301.1 Exterior Design Conditions.
301.2 Indoor Design Conditions .....	301.2 Indoor Design Conditions.
CHAPTER 4 BUILDING DESIGN REQUIREMENTS .....	Subpart D—Building Design Requirements
ELECTRIC SYSTEMS AND EQUIPMENT	
401 Electrical Power and Lighting Systems .....	434.401 Electrical Power and Lighting Systems.
401.1 Electrical Distribution Systems .....	401.1 Electrical Distribution Systems.
401.1.1 Check Metering .....	401.1.1 Check Metering.
401.1.2 Electrical Schematic .....	401.1.2 Electrical Schematic.
401.2 Electric Motors .....	401.2 Electric Motors.
401.2.1 Efficiency .....	401.2.1 Efficiency.
LIGHTING SYSTEMS AND EQUIPMENT	
401.3 Lighting Power Allowance .....	401.3 Lighting Power Allowance.
401.3.1 Building Exteriors .....	401.3.1 Building Exteriors.
401.3.2 Building Interiors .....	401.3.2 Building Interiors.
401.3.3 Lighting Power Control Credits .....	401.3.3 Lighting Power Control Credits.
401.3.4 Lighting Controls .....	401.3.4 Lighting Controls.
401.3.5 Ballasts .....	401.3.5 Ballasts.
BUILDING ENVELOPES	
402 Building Envelope Assemblies and Materials .....	434.402 Building Envelope Assemblies and Materials.
402.1 Calculations and Supporting Information .....	402.1 Calculation and Supporting Information.
402.1.1 Materials Properties .....	402.1.1 Materials Properties.
402.1.2 Thermal Performance Calculations .....	402.1.2 Thermal Performance Calculations.
402.1.3 Gross Areas of Envelope Components .....	402.1.3 Gross Areas of Envelope Components.
402.2 Air Leakage and Moisture Migration .....	402.2 Air Leakage and Moisture Migration.
402.2.1 Air Leakage .....	402.2.1 Air Barrier System.
402.2.2 Exterior Envelope Joints and Penetrations .....	402.2.2 Building Envelope.
402.2.3 Moisture Migration .....	402.2.3 Moisture Mitigation.
402.3 Thermal Performance Criteria .....	402.3 Thermal Performance Criteria.
402.3.1 Roofs; Floors and Walls Adjacent to Unconditioned Spaces.	402.3.1 Roofs; Floors and Walls Adjacent to Unconditioned Spaces.
402.3.2 Below-Grade Walls and Slabs-on-Grade .....	402.3.2 Below-Grade Walls and Slabs-on-Grade.
402.4 Exterior Walls .....	402.4 Exterior Walls.
402.4.1 Prescriptive Criteria .....	402.4.1 Prescriptive Criteria.
402.4.2 System Performance Criteria .....	402.4.2 System Performance Criteria.
BUILDING MECHANICAL SYSTEM AND EQUIPMENT	
403 Building Mechanical Systems and Equipment .....	434.403 Building Mechanical Systems and Equipment.
403.1 Mechanical Equipment Efficiency .....	403.1 Mechanical Equipment Efficiency.
403.2 HVAC Systems .....	403.2 HVAC Systems.
403.2.1 Load Calculations .....	403.2.1 Load Calculations.
403.2.2 Equipment and System Sizing .....	403.2.2 Equipment and System Sizing.
403.2.3 Separate Air Distribution System .....	403.2.3 Separate Air Distribution System.
403.2.4 Ventilation and Fan System Design .....	403.2.4 Ventilation and Fan System Design.
403.2.5 Pumping System Design .....	403.2.5 Pumping System Design.
403.2.6 Temperature and Humidity Controls .....	403.2.6 Temperature and Humidity Controls.
403.2.7 Off-Hour Controls .....	403.2.7 Off-Hour Controls.
403.2.8 Economizer Controls .....	403.2.8 Economizer Controls.

**Table 2.—SUBJECT CROSS WALK BETWEEN CODIFIED VERSION OF STANDARD 90.1–1989 AND THE PROPOSED FEDERAL RULE—Continued**

Codified 90.1–1989	Proposed rule
403.2.9 Distribution System Construction and Insulation .....	403.2.9 Distribution System Construction and Insulation.
403.2.10 Completion .....	403.2.10 Completion.
BUILDING SERVICE SYSTEMS AND EQUIPMENT	
404 Building Service Systems and Equipment .....	434.404 Building Service Systems and Equipment.
404.1 Service Water Heating Equipment .....	404.1 Service Water Heating Equipment Efficiency.
404.1.1 Testing Electric and Oil Storage Water Heaters for Standby Loss.	404.1.1 Testing Electric and Oil Storage Water Heaters for Standby Loss.
404.1.2 Unfired Storage Tanks .....	404.1.2 Unfired Storage Tanks.
404.1.3 Storage Volume Symbols in Table .....	404.1.3 Storage Volume Symbols in Table.
404.2 Service Hot Water Piping Insulation .....	404.2 Service Hot Water Piping Insulation.
404.3 Service Water Heating System Controls .....	404.3 Service Water Heating System Controls.
404.4 Water Conservation .....	404.4 Water Conservation.
404.5 Swimming Pools .....	404.5 Swimming Pools.
404.6 Combined Service Water Heating and Space Heating Equipment.	404.6 Combined Service Water Heating and Space Heating Equipment.
The codified version of Standard 90.1–1989, Section 102, Compliance, incorporates by reference the Building Energy Cost Compliance Alternative.	Subpart E—Building Energy Cost Compliance Alternative
	434.501 General.
	434.502 Determination of the Annual Energy Cost Budget.
	434.503 Prototype Building Procedure.
	434.504 Use of the Prototype Building to Determine the Energy Cost Budget.
	434.505 Reference Building Method.
	434.506 Use of the Reference Building to Determine the Energy Cost Budget.
	434.507 Calculation Procedure and Simulation Tool.
	434.508 Determination of the Design Energy Consumption and Design Energy Cost.
	434.509 Compliance.
	434.510 Standard Calculation Procedure.
	434.511 Orientation and Shape.
	434.512 Internal Loads.
	434.513 Occupancy.
	434.514 Lighting.
	434.515 Receptacles.
	434.516 Building Exterior Envelope.
	434.517 HVAC Systems and Equipment.
	434.518 Service Water Heating.
	434.519 Controls.
	434.520 Speculative Buildings.
	434.521 The Simulation Tool.
The Building Energy Compliance Alternative is not in the codified version.	Subpart F—Building Energy Compliance Alternative
	434.601 General.
	434.602 Determination of the Annual Energy Budget.
	434.603 Determination of the Design Energy Use.
	434.604 Compliance.
	434.605 Standards Calculation Procedures.
	434.606 Simulation Tool.
	434.607 Life Cycle Cost Analysis Criteria.
CHAPTER 5 REFERENCE STANDARDS .....	Subpart G—Reference Standards
501 General .....	434.701 General.

As stated earlier, this proposed rule is being published in a unified and easy access form in lieu of publishing changes from the codified version of Standard 90.1 due to the integrated nature of the changes (small and large) from the codified version. In addition, this unified approach will facilitate the updating of this rule to reflect new energy efficiency provisions.

DOE worked with the ASHRAE's Standing Standards Project Committee 90.1 and the IES's Energy Management Committee in their development of addenda to Standard 90.1–1989. Today, the DOE is proposing to include some of these addenda in its proposed rule. Table 3 provides a subject cross walk between addenda to Standard 90.1–1989 and the proposed rule.

**TABLE 3.—SUBJECT CROSS WALK BETWEEN STANDARD 90.1–1989 ADDENDA AND THE PROPOSED FEDERAL RULE**

Standard 90.1–1989 Addenda	Proposed rule
Add. a Not promulgated .....	

TABLE 3.—SUBJECT CROSS WALK BETWEEN STANDARD 90.1–1989 ADDENDA AND THE PROPOSED FEDERAL RULE—  
Continued

Standard 90.1–1989 Addenda	Proposed rule
Add. b Revises service water heating criteria and updates miscellaneous references to other standards in Section 11 of ASHRAE Standard 90.1–1989.	Subpart D Building Design Requirements— 404 Includes reference changes and addenda to service water heating criteria.
Add. c Motors. Makes the motor efficiency requirements more stringent and updates and adds references to NEMA Standards.	Subpart D Building Design Requirements— 401.2 Electric Motors.
Add. d Clarifies the Exception under 6.4.2.5, Lighting controls in spaces used as a whole.	Subpart D Building Design Requirements— 401.3.3 Lighting Power Control Credits.
Add. e Clarifies wording of 9.4.7, Ventilation. Section 9.4.7.2 permits outside air intake to exceed minimum levels provided the system is capable of operating at the minimum levels specified by 6.1.3 of ASHRAE Standard 62.	Subpart D Building Design Requirements— 403.2.4 Ventilation and Fan System Design.
Add. f Fenestration. Not adopted but pending consideration by ASHRAE.	Subpart D Building Design Requirements— 402.4.1.2 Fenestration DOE is proposing substantive provisions that are the same as in proposed Addendum F. DOE's version is written in codified form. Contains corrections in the fenestration thermal performance calculation procedure to meet industry standards. Includes changes to the alternative Component (ACP) Tables to reflect this change.
Add. g Expansion of Table 8C–2, Wall Sections with Metal Studs, Parallel Path Correction Factors. Addresses thicker wall members and new technology for higher performance insulation products.	Subpart D Building Design Requirements— 402.1.2.1 Envelope Assemblies Containing Metal Framing
Add. h Not promulgated	
Add. i Modifications to tables of HVAC equipment performance criteria in Section 10. (These were first included in Addenda a.) Incorporates updated test-procedure reference to the HVAC equipment performance criteria.	Subpart D Building Design Requirements— 403.1 Mechanical Equipment Efficiency.

#### *E. Explanation of Differences Between the Proposed Rule and the Statutory Baseline*

This section explains the differences between the proposed rule and the statutory baseline. As noted above, this baseline includes Addenda b, d, and e, since they were in effect at the time EPACT was enacted. The discussion below corresponds to the sections in the proposed rule. Unless otherwise indicated, the proposed rule incorporates the language of the codified version of both Standard 90.1 and its addenda. Minor language changes and citation changes will not be noted.

#### **Subpart A: Administration and Enforcement**

Sections 434.100 and 434.101, Purpose and Scope. In these proposed sections, the title, purpose and scope would be changed from the codified version and the statutory baseline to reflect the application to federal sector buildings. These sections would adopt language from the interim rule, with some modifications, which define the purpose of the proposed rule and the categories of buildings covered by this rulemaking. Specifically, the purpose section would use the term “energy efficiency” instead of the term “energy conservation” which is used in the codified version. Proposed § 434.101,

Scope, would delete exception (1), which appears in both the statutory baseline and the codified version. Unlike the statutory baseline, the proposed rule specifically lists all the exceptions within the “Scope” section.

Sections 434.104, 106, and 107 Reserved

The proposed rule does not include the sections entitled “Validity,” “Plans and Specifications,” and “Inspections” from the codified version. The statutory baseline does not contain any of these sections either.

#### **Subpart B: Definitions**

The proposed rule would change the definition of “commercial building” from the codified version by using the definition of “commercial building” from the interim rule, which is identical to the definition in ECPA, as amended, 42 U.S.C. 6832(4). The proposed rule would also add several other definitions from the interim rule that are not in the codified version. They are: building code, Federal agency, Federal building and multi-family high-rise residential buildings. All of these definitions, except for multi-family high rise residential buildings, are identical to the definitions in ECPA, as amended, 42 U.S.C. 6832(3), (5), and (6), respectively.

#### **Subpart D: Building Design Requirements**

Section 401.2, Electric Motors. This proposed section would include Addendum c regarding motor efficiency. This is not part of the statutory baseline. These revised minimum efficiencies for electric motors are identical to those set forth in section 342(b) of the Energy Policy and Conservation Act (EPCA) as amended by section 122(d) of EPACT. The codified version of Addendum c is used with the exception of Table 401.2.1 of the proposed rule, which is from Table 5.1 of the non-codified version of the addendum. The codified version of Table 401.2.1 is condensed from the non-codified version and does not include as broad a range of motor types. The effect of including Addendum c is to make section 401.2 of the proposed rule more energy efficient than the statutory baseline. See, Technical Support Document (TSD), pages 2–3.

Section 401.3.2, Building Interiors. This proposed section would adopt most of the lighting requirements of the interim rule. Those lighting requirements incorporated from the interim rule are more energy efficient than the statutory baseline; the remaining requirements are identical to the statutory baseline. See, Technical Support Document, pages 3–7.

The interim federal rule specifies two sets of maximum unit power density

values (UPD). UPD is measured as lighting watts per square foot of floor area. The initial (1989) values are the same as those in the codified version of Standard 90.1–1989. It also contains more energy efficient UPD values that took effect in 1993. The values proposed today have been updated to reflect the results of the detailed assessment of the 1993 interim values made during a demonstration phase of the applicability of the interim rule. These values reflect a goal of progressive energy-conserving practice without prohibiting the design of quality lighting in interior environments.

The proposed rule would include UPD values in Tables 401.3.2b and 401.3.2c that in most cases are more stringent than the statutory baseline for various area/space categories. The proposed rule would adopt 79 of the 106 space types listed at the more stringent 1993 UPD values and 27 of the 106 space types listed at the 1989 UPD values from the interim rule. In no case is more lighting energy allowed than provided for under Standard 90.1–1989. See, Technical Support Document, page 4.

In the proposed rule, offices have a high number of recommended UPD values from the 1993 values of the interim rule because the substantial amount of case study and simulation evidence points overwhelmingly to a current capability for further reducing office lighting energy use without sacrificing lighting quality. The large amount of office space in the United States means that even this small improvement in energy efficiency specifications will result in significant additional energy savings. In only one case is a 1993 office value retained at the 1989 UPD value.

Sections 402.1.1.1, Shading Coefficient, and 402.1.2.2, Envelope Assemblies Containing Nonmetal Framing. The reference in the last sentence of Section 402.1.1.1 is Table 41, Chapter 27, of the ASHRAE, Handbook, 1989 Fundamentals Volume rather than the reference found in the codified version to Table 41 of the older 1985 Handbook. The 1985 Handbook is also referenced in the statutory baseline. There is no difference in the content of these tables, simply a different table number in the two versions of the Handbook.

The reference in the last sentence of Section 402.1.2.2 is changed from page 23.2 of Chapter 23 of the ASHRAE, Handbook, 1985 Fundamentals Volume found in the codified version and the statutory baseline, to page 23.2 of Chapter 23 of ASHRAE, Handbook, 1989 Fundamentals Volume. This

updated reference is not substantive in nature.

Section 402.1.2.1, Envelope Assemblies Containing Metal Framing. The proposed rule would adopt Addendum 90.1g, which is not part of the statutory baseline. Addendum 90.1g expands proposed Table 402.1.2.1b, Parallel Path Correction Factors, Metal Framed Walls with Studs 16 Gauge or Lighter, to include metal studs and a larger variety of insulation products in exterior wall framing. These technologies are not required. The table is expanded to make it easier for builders to use these technologies. See, Technical Support Document, page 9.

Section 402.1.2.4, Fenestration Assemblies. The proposed rule would change the rating method for fenestration (windows and skylights) from that used in the statutory baseline. The proposed Section 402.1.2.4, which mirrors proposed ASHRAE Addendum f, differs from the statutory baseline in two respects. First, the proposed rule would adopt the test procedure of the National Fenestration Rating Council (NFRC), NFRC 100–91, Procedure for Determining Fenestration Product Thermal Properties (currently limited to thermal transmittance value). This test procedure modifies the method of calculating the thermal transmittance of fenestration assemblies (e.g., framing and glazing). Second, the thermal transmittance values in Equation 402.1.2.3, referenced in the proposed section, would be updated to reflect the new rating procedure so that the minimum required window assemblies would be essentially the same as those required under Standard 90.1–1989 using the old rating method. See, Technical Support Document, pages 10–11.

The new testing procedure was developed by a consensus process supported by the Department under section 121 of EPACT. The Department is proposing to adopt the NFRC Test Procedure because this method provides a more accurate measure of energy efficiency. In addition to being the basis for proposed Addendum 90.1f to Standard 90.1–1989 now under consideration by the ASHRAE Standing Standards Project Committee, it is already referred to in Chapter 27 of the 1993 ASHRAE Handbook of Fundamentals. As noted previously in Section II.D. above, proposed Addendum f is not included in the codified version.

Section 402.4.1.2, Fenestration. The revised tables 402.4.1.1 on maximum wall thermal transmittance overall and 402.4.1.2 on maximum window wall ratio (WWR) were created using the new

method of calculating the thermal transmittance of fenestration described above. These revised tables incorporate the changes in fenestration test procedures and required thermal transmittance overall values specified in Section 402.1.2.4.

Section 403.1, Mechanical Equipment Efficiency. The proposed rule adopts the changes set forth in Addendum 90.1i, which are not part of the statutory baseline. These changes update the Test Procedure column in the HVAC Tables 403.1a through 403.1f, to reflect the latest references in mechanical equipment efficiency test procedures to ensure consistency with industry practice. Addendum 90.1i also changes the required minimum cubic feet per minute (cfm) for variable-air-volume (VAV) systems to 300 cfm in order to provide consistency with the minimum requirements of Section 403.2.4, Ventilation and Fan System Design (Addendum 90.1e) See, Technical Support Document, pages 12–14. Addendum 90.1e, which is part of the statutory baseline, permits outside air intake to exceed the minimum levels established by Standard 90.1–1989, to increase indoor air quality and tenant comfort.

#### Subpart E, Building Energy Cost Compliance Alternative

This provision is part of the statutory baseline. It is incorporated in the codified version of Standard 90.1–1989 by reference only (see Section 102, Compliance). The language of this subpart has been adopted in its entirety from the interim rule, with the exception of paragraphs 11.2.3, 11.2.4 and 11.3.1 found in § 435.111. The language in paragraph 11.2.3, which is contained in Section 502.3 of the proposed rule would be modified to make it more clear. The language in paragraph 11.2.4 would be deleted because it is merely explanatory in nature and does not include any regulatory requirements. The language in paragraph 11.3.1, which is contained in Section 508.1 of the proposed rule, has been modified to avoid confusion regarding which energy supply sources the section applies to.

This subpart sets forth the requirements for using one of two alternative methods of whole building performance compliance. This alternative method is based on a comparison of expected local monthly energy costs for the proposed building design (referred to as the “design energy cost”) to the expected energy costs of a similar building designed to just meet the specific requirements of subpart D (referred to as the “energy cost budget”).

Compliance is achieved when the estimated design energy cost is less than or equal to the energy cost budget. Subpart E provides instructions for determining the budget and for calculating energy analysis of prototype or reference building designs configured to meet the prescriptive or systems requirements of the standards.

The prototype or reference building design for the energy cost budget (1) incorporates the minimum technical specifications in proposed subpart D and (2) is based on the least expensive energy source(s) (e.g. electricity, natural gas, or oil) for space and water heating. The reference energy source(s) is not a requirement or recommendation.

This approach allows a designer maximum flexibility in the design process, while ensuring that the building is designed to have energy cost no higher than costs under the other compliance paths. This path provides an opportunity for the energy conservation benefits of innovative designs, materials, and equipment to be used when they cannot be evaluated adequately under either the prescriptive or system performance procedures.

#### Subpart F, Building Energy Compliance Alternative

This subpart is not found in the statutory baseline or the codified version of Standard 90.1-1989. The Building Energy Compliance Alternative has been adopted in its entirety from the current interim rule (See 10 CFR 435.112), with the exception of a portion of paragraph 12.1.7 from § 435.112, which would be deleted to conform to 10 CFR part 436. (See Proposed Section 601.7). The proposed rule would also modify the language of paragraphs 12.3.2.1 and 12.7.1 from § 435.112, now contained in proposed Sections 603.2.1 and 607.1, respectively. In the first instance, the modification would clarify the language of the proposed section; in the latter instance, the modification would conform the proposed section to part 436 and simplify it. Finally, a portion of paragraph 12.7.1.4 from § 435.112 would be deleted in order to make proposed Section 607.1.4 accurate.

This subpart provides an additional alternative path for compliance with the proposed rule which is based on a comparison of total energy use rather than energy costs as in subpart E. Compliance under this subpart is demonstrated by showing that the calculated annual energy usage for the proposed building design is equal to or less than a calculated design energy use target based on just meeting the requirements of subpart D.

A life-cycle cost economic analysis is required to evaluate both the choice of energy source(s) and energy reduction strategies. Unlike subpart E, this subpart requires the use of the energy source(s) determined to have the lowest life-cycle cost. Fuel sources selected for the proposed design and prototype or reference buildings are determined by considering the energy costs and other costs and benefits that occur during the expected economic life of the alternative. The procedures set forth in subpart A of 10 CFR part 436 are used to make the determination.

When the proposed design is compared to the prototype or reference building, the same subsystems and fuel sources are used so that the subsystems of each correspond. Life-cycle cost analysis is then used to determine whether proposed features would be cost-effective to the federal government. (Section IV of this preamble discusses federal policies which promote the purchase of cost-effective energy efficiency investments.)

#### Subpart G, Reference Standards

The proposed rule would adopt the reference section from the codified version of Standard 90.1-1989 with several additions. Several of these changes are described above. In addition, several references to other building industry standards are being updated to be consistent with the current version of those standards. These changed references are: RS-4, *ASHRAE, Handbook of Fundamentals, 1985* which was updated to version 1989 and RS-48 which was updated to version 1993. Specifically, added reference standards include: RS-43, *NEMA MG 10-1983 (R 1988)*, Energy Management Guide for Selection and Use of Polyphase Motors, National Electrical Manufacturers Association, Washington, D.C. 20037; RS-44, *NEMA MG 11-1977 (R 1982, 1987)*, Energy Management Guide for Selection and Use of Single-Phase Motors, National Electrical Manufacturers Association, Washington, D.C. 20037; RS-45, *ARI Standard 330-93*, Ground-Source Closed Loop Heat Pumps, Air-Conditioning and Refrigeration Institute, Arlington, Va. 22209; RS-46, *ARI Standard 560-92*, Absorption Water Chilling and Water Heating Packages, Air-Conditioning and Refrigeration Institute, Arlington, Va. 22209; RS-47, *ASHRAE, Handbook, 1991 Applications Volume*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA 30329; RS-48, *ASHRAE, Handbook, 1993 Fundamentals Volume*, American Society of Heating, Refrigerating, and

Air-Conditioning Engineers, Atlanta, GA 30329; and RS-49, *Codified Version of ASHRAE, Standard 90.1-1989*, Energy Code For Commercial And High-Rise Residential Buildings, including Addenda b, c, d, e, g, and i.

#### III. Consultation

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

#### IV. Energy Impacts

Section 305(a)(2)(A) of ECPA, as amended, requires that the proposed rule meet or exceed Standard 90.1-1989. As stated above, DOE is interpreting the statutory reference to Standard 90.1-1989 to include addenda in effect when EPACT was enacted. The proposed rule includes all of the energy efficiency provisions in the statutory baseline including the addenda in effect as of October 24, 1992. It also includes the three addenda adopted since October 24, 1992 (Addenda c, g and i), and lighting specifications that are not included in either Standard 90.1-1989 or any of its addenda. Further, DOE proposes requirements based upon proposed Addendum f.

Overall, the proposed rule, if adopted, for new federal buildings, would reduce energy use by about 5 percent more than adoption of a rule that meets the statutory baseline. The Department has determined that Addenda g and i, addressing metal stud walls and HVAC performance testing, respectively, as well as proposed Addendum f have no impact on energy use. The Department estimates that Addendum c provides a 0.24 percent reduction in building energy use. This same reduction will be realized nationwide as the electric motor standards of section 342 (b) of the EPCA, as amended, take effect. The Department has also determined that the proposed lighting standards will result in total building energy use which is 4.7 percent less than that allowed by the statutory baseline.

Even though today's proposed rule is more stringent than the statutory baseline, two components of the proposed rule are likely to result in an increase in allowed energy use as compared to the interim rule. First, the interim rule does not include the new ventilation standard found in the statutory baseline, Addendum e of Standard 90.1-1989. Addendum 90.1e requires inclusion of capacity to provide more fresh air to be brought into commercial buildings in order to improve indoor air quality and occupant



comfort. The Department estimates that the additional energy needed to heat, cool, dehumidify and move this additional outdoor air will increase energy use under the proposed rule by 10 to 15 percent from the energy requirements in the interim standard.

Second, for 27 of the 106 space types, the lighting requirements in the proposed rule are less stringent than the 1993 lighting values in the interim rule. The changes are unlikely, however, to have much impact on energy use since the 1993 UPD values proved difficult to implement for these 27 space types.

The energy estimates reported here are based on the minimum specifications found in Subsection D of the proposed rule. Additional cost-effective energy efficiency improvements in new federal commercial buildings are facilitated by this rule through subparts E and F, the alternative paths which provide a means of documenting the energy savings and cost-effectiveness of more energy efficient building designs. Pursuant to section 306 of ECPA, as amended, federal agencies must adopt building standards which meet or exceed the standards of the proposed rule. Utilization of the voluntary code format for this rule would facilitate DOE's consideration and incorporation of new code specifications. The Department is actively involved in the development and analysis of a next-generation voluntary code for commercial buildings.

Several existing programs and policies are also designed to reduce energy use in new federal buildings beyond minimum specifications. The proposed rule is specifically designed to work in conjunction with existing efforts. The life cycle cost analysis provisions found in 10 CFR part 436 allow agencies to determine when additional or alternative efficiency measures would provide net benefits in the form of energy cost savings to ensure that measures selected under the alternative paths are cost-effective to the Federal government. Section 306(a) of Executive Order No. 12902 (59 FR 11463, March 8, 1994), "Executive Order on Energy Efficiency and Water Conservation at Federal Facilities," specifically requires for new Federal facilities 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." 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). Finally, this Executive Order directs agencies to purchase equipment for buildings that are in the upper 25 percent of energy efficiency for all similar products or at least 10 percent more efficient than the minimum level that meets Federal standards if they are cost-effective and to the extent practicable. Section 507(a)(2). Programs within the Department's Office of Codes and Standards and the Federal Energy Management Program provide agencies with assistance in utilizing life-cycle cost analysis and in identifying and procuring energy efficient shell and equipment options for Federal buildings.

#### V. Technological Feasibility and Economic Justification

The standards proposed today are technologically feasible and cost effective to the federal government as required by section 305(a)(1) of ECPA, as amended. Those provisions included in the statutory baseline have been part of recommended professional practice since at least October 1992. Addenda adopted or proposed by ASHRAE and IES since EPACT was enacted (Addenda 90.1c, f, g, and i addressing motors, fenestration, metal framing in the building envelope, and heating and cooling equipment test procedures, respectively) will be addressed specifically to explain their technological feasibility and cost effectiveness.

Addendum 90.1c, regarding motors was developed in cooperation with the National Electrical Manufacturers Association and is based on its standards. Motors covered by this criteria are currently being actively marketed by manufacturers and regularly incorporated as cost effective retrofit measures in utility demand side management programs. See, Technical Support Document, page 3. Section 342(b) of EPCA, as amended, governs the efficiency of motors manufactured after October 1997. Discussions with manufacturers lead DOE to believe that these products will be cost effective for all new federal buildings at the time this rule would become effective.

Proposed Addendum 90.1f modifies the method of calculating the thermal transmittance of fenestration assemblies based on the National Fenestration Rating Council's procedures for

determining fenestration thermal performance. Over 12,000 products have been certified using this procedure. Hence, the Department believes that these procedures are technologically feasible. Furthermore, DOE believes that the U-values specified in the proposed rule based on Addendum f would not change the types of windows from those required by Standard 90.1-1989. A review of the National Fenestration Products Rating Council Certified Product Directory leads DOE to conclude that the proposed changes will not require a change in fenestration from the statutory baseline. See, Technical Support Document, pages 10-11.

Addendum 90.1g, expands proposed Table 402.1.2.1b, Parallel Path Correction Factors, Metal Framed Walls with Studs 16 Gauge or Lighter, to include a larger variety of available types of metal studs, spacing of framing members and cavity insulation values which are being used for exterior walls. This was done in light of recent increased interest in metal shed construction. The proposed rule only permits the use of metal studs if the exterior wall is properly insulated; it does not require the use of this technology. The Department believes this technology will be used only in cases where the builder finds it is cost effective to do so. See, Technical Support Document, pages 8-9.

Addendum 90.1i updates the test procedures for heating and cooling equipment. Their adoption by equipment manufacturers demonstrates their technological feasibility. Furthermore, since these are established testing procedures used by industry, DOE believes their inclusion in the proposed rule will have no impact on cost. In addition, Addendum 90.1i specifies minimum air changes per hour under various circumstances. DOE believes this will not increase energy use beyond the statutory baseline since Addendum e, adopted prior to October 24, 1992 already allowed this practice. See, Technical Support Document, pages 12-14.

The proposed rule adopts those 1993 lighting specifications that proved to be both technologically feasible and cost-effective. (See Appendix of the TSD). For each of the 79 space/area types for which the Department is proposing to use the 1993 UPD values from the interim rule, these values proved to be both technologically feasible and cost-effective to the federal government. For each of the 27 space/area types for which the Department is proposing to use the 1989 values from the interim rule (identical to the statutory baseline),

the Department's analysis indicated potential technical difficulties in using the 1993 UPD values while retaining adequate lighting levels for the relevant tasks. In determining the cost-effectiveness of the lighting provisions, the original analysis was adjusted to reflect the estimated lower cost of electricity to the federal government. See, Technical Support Document, pages 3-7.

#### VI. Measures Concerning Radon and Other Indoor Air Pollutants

Section 305(a)(2)(C) of ECPA, as amended, requires the Department to consider, where appropriate, measures with regard to radon and other indoor air pollutants. The Department has consulted with the Environmental Protection Agency and determined that there are no radon standards applicable to the types of buildings covered by the proposed rule.

Ventilation is the only proposed change that has an effect on indoor air quality and thus, on habitability. The proposed rule, through its inclusion of Addendum 90.1e, would adopt the minimum ventilation rates specified by ASHRAE Standard 62-1989, entitled "Ventilation for Acceptable Indoor Air Quality," effectively increasing ventilation in new federal buildings. Improving building ventilation conditions by adjustments to mechanical systems is widely used as a generic mitigation practice for indoor air quality problems. It is widely assumed that such adjustments increase ventilation rates and as a consequence decrease contaminant concentrations, reduce dissatisfaction with air quality and reduce symptom prevalence. A range of experimental and epidemiological studies have been carried out to evaluate these relationships. However, these study results are in dispute.

#### VII. Findings and Certification

##### A. 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 policy action.

This proposed rule would establish standards for new federal commercial and multi-family high rise 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 and, therefore, a federalism assessment has not been prepared.

##### B. Review Under Executive Order on Promulgating Regulations 12988

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 judicial review and any provisions for the exhaustion of administrative remedies. The Department certifies that the proposed rule meets the requirements of section 3(a) and (b) of Executive Order 12988.

##### 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. 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 commercial and multi-family high rise 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.

##### E. Review Under the National Environmental Policy Act

In issuing the interim rule, the Department prepared an Environmental Assessment (EA) of the interim standards for Federal commercial and multi-family high rise residential buildings. The EA concluded that the effect of the proposed standards on a building's habitability as well as on the outdoor environment, the economy and Federal institutions, would be very small. Thus, environmental effects from standards proposed for a minimum level of energy efficiency for new Federal and commercial multi-family high rise residential buildings were determined not to be a major Federal action significantly affecting the quality of the human environment, under the meaning of the National Environmental Policy Act. A Finding of No Significant Impact (FONSI) was issued by DOE on November 3, 1986. The FONSI was then published along with the proposed rule in 52 FR 17052, 17064 (May 6, 1987) and referenced in the interim rule in 54 FR 4551 (January 30, 1989).

The 1989 interim rule that established building energy efficiency standards was mandatory for federal buildings and voluntary for all others. This proposed rule addresses solely federal construction, which represents only 2 percent of total new construction nationwide, and does not include voluntary standards for non-federal construction.

The proposed rule would change energy consumption as compared to the interim rule in the areas of lighting, motors, and HVAC. In conducting the environmental analysis for this proposed rule, the Department found that the proposed changes would produce a 4.7 percent reduction in building energy consumption compared to the 1989 lighting criteria in the interim rule. The proposed rule would also produce a 0.24 percent reduction in building energy consumption due to the proposed efficiency requirements of motors as compared to the interim rule. The proposed rule, however, could increase energy use by 10-15 percent, because of the additional HVAC requirements of Addendum 90.1e, as compared to the interim rule. The net result would be an approximate 5-10 percent increase in total building energy use as compared to the interim rule with the 1989 lighting levels. Since federal construction represents only 2 percent of the total new commercial and multi-family high-rise construction nationally,

the increase in energy consumption nationally would be negligible.

The Department believes that a minimum environmental impact would result from this proposed rule. Further, such effects would fall within the range of impacts that are analyzed in the interim rule's EA. These effects are determined not to be significant in the FONSI published in 1987. Accordingly, DOE determines that after all the environmental effects of the proposed rule are considered, this proposed rule is bounded by the analysis in the EA. Therefore, the preparation of a new EA or an environmental impact statement is not required.

#### *F. 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.

#### *G. 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 commercial and multi-family high rise 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.

#### *H. 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. See 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 commercial and multi-family high rise 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.

#### *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 of Energy is required to comply with section 32 of the Federal Energy Administration Act of 1974, as amended by section 9 of the Federal Energy Administration Authorization Act of 1977. The findings required of the Department of Energy 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 of Energy 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 codified version of Standard 90.1-1989, including six addenda adopted by ASHRAE/IES. They are: Addenda b, c, d, e, g, and i. In addition, the proposed rule contains other industry reference standards and sources. They are: ASHRAE, Handbook, 1989, 1993, Fundamentals Volumes, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA. 30329; National Fenestration Rating Council (NFRC) 100-91, Procedure for Determining Fenestration Product Thermal Properties, Silver Spring, MD. 20910; NEMA MG 10-1983 (R 1988), Energy Management Guide for Selection and Use of Polyphase Motors, National Electrical Manufacturers Association, Washington, DC 20037; NEMA MG 11-1977 (R 1982, 1987), Energy Management Guide for Selection and Use of Single-Phase Motors, National Electrical Manufacturers Association, Washington, DC, 20037; ARI Standard 330-93, Ground-Source Closed Loop Heat Pumps, Air-Conditioning and Refrigeration Institute, Arlington, Va. 22209; ARI Standard 560-92, Absorption Water Chilling and Water Heating Packages, Air-Conditioning and Refrigeration Institute, Arlington, Va. 22209; and ASHRAE Handbook, 1991 Applications Volume, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA 30329.

The Department of Energy 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, DOE now invites public comment on the appropriateness of incorporating these industry standards in its final rule. As required by section 32(c), DOE 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.

#### **VIII. Public Comment Procedures**

##### *A. Participation in Rulemaking*

The Department encourages the maximum level of public participation in this rulemaking. Individuals, Federal agencies, architects, engineers, utilities, States and local governments, building

code organizations, builders, builder associations, building owners, building owner association, consumers, and others are urged to submit written data, views, or comments on the proposal. Whenever applicable, full supporting rationale, data and detailed analyses should also be submitted. The Department also encourages interested persons to participate in the public hearing to be held in Washington, DC, at the time and place indicated in this Notice.

The Department has established a comment period of 90 days following publication of this notice during which interested persons may comment on this proposal. All comments will be available for review in the Department's Freedom of Information Reading Room.

#### *B. Written Comment Procedures*

Written comments (ten copies) should be submitted to the address indicated in the ADDRESSES section of this notice and must be received by the time and 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 Code for New Federal Commercial and Multi-Family High Rise Residential Buildings (Docket No. EE-RM-79-112-C)." In the event any person wishing to provide written comments cannot provide ten copies, alternative arrangements can be made in advance with DOE by calling.

All comments received on or before the date specified at the beginning of this notice and other relevant information will be considered by DOE 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 notice both 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 or data 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 claimed to be confidential has been deleted. The Department will make its own determination of any such claim and treat it according to its determination.

#### *C. Public Hearing Procedures*

##### *1. Procedure for Submitting Requests to Speak*

In order 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 in the proposed rule or who is a representative of a group or class of persons that has an interest in the proposed rule may request an opportunity to make an oral presentation. Requests to speak should be sent to the address or phone number indicated in the **ADDRESSES** section of this notice and received by the time specified in the **DATES** section of this notice.

The persons 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 also should provide a telephone number where they may be contacted during the day. Each person selected to speak at a public hearing will be notified by the DOE as to the approximate time that they will be speaking. They should bring ten copies of their statement to the hearing. In the event any person wishing to testify cannot meet this requirement, alternative arrangements can be made in advance with DOE.

##### *2. Conduct of Hearing*

The DOE reserves the right to select persons to be heard at the hearings, to schedule their presentations, and to establish procedures governing the conduct of the hearing. The length of each presentation is limited to ten minutes, or based on the number of persons requesting to speak.

A Department official will preside at the hearing. The hearing will not be a judicial or evidentiary-type hearing, but 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 will be given the opportunity to make a rebuttal statement. The rebuttal statements will be given in the order in which the initial statements were made.

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 Officer at the hearing.

If DOE must cancel the public hearing, DOE will make every effort to publish an advance notice of such cancellation in the Federal Register. Actual notice of cancellation will also be given to all persons scheduled to speak. The hearing date may be cancelled in the event no member of the public requests the opportunity to make an oral presentation.

List of subjects in 10 CFR Parts 434 and 435

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

Issued in Washington, DC, on July, 1996.

Christine A. Ervin,

*Assistant Secretary, Energy Efficiency and Renewable Energy.*

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

#### **PART 435—ENERGY CONSERVATION VOLUNTARY PERFORMANCE STANDARDS FOR NEW BUILDINGS; MANDATORY FOR FEDERAL BUILDINGS**

1. The authority citation for part 435 is revised to read as follows:

Authority: 42 USC 6831–6832; 6834–6836; 42 USC 8253–54; 42 USC 7101 et seq.

##### **§§ 435.97 through 435.112 (Subpart A) [Removed and reserved]**

2. Subpart A (§§ 435.97 through 435.112) to part 435 is removed and reserved.

3. A new part 434 is added to Chapter II of Title 10 to read as set forth below:

#### **PART 434—ENERGY CODE FOR NEW FEDERAL COMMERCIAL AND MULTI-FAMILY HIGH RISE RESIDENTIAL BUILDINGS**

Sec.

434.99 Explanation of numbering system for codes.

##### **Subpart A—Administration and Enforcement—General**

- 434.100 Purpose.
- 434.101 Scope.
- 434.102 Compliance.
- 434.103 Referenced standards (RS).
- 434.105 Materials and equipment.

##### **Subpart B—Definitions**

- 434.201 Definitions.

**Subpart C—Design Conditions****434.301 Design Criteria.****Subpart D—Building Design Requirements—Electric Systems and Equipment**

- 434.401 Electrical power and lighting systems.
- 434.402 Building envelope assemblies and materials.
- 434.403 Building mechanical systems and equipment.
- 434.404 Building service systems and equipment.

**Subpart E—Building Energy Cost Compliance Alternative.**

- 434.501 General.
- 434.502 Determination of the annual energy cost budget.
- 434.503 Prototype building procedure.
- 434.504 Use of the prototype building to determine the energy cost budget.
- 434.505 Reference building method.
- 434.506 Use of the reference building to determine the energy cost budget.
- 434.507 Calculation procedure and simulation tool.
- 434.508 Determination of the design energy consumption and design energy cost.
- 434.509 Compliance.
- 434.510 Standard calculation procedure.
- 434.511 Orientation and shape.
- 434.512 Internal loads.
- 434.513 Occupancy.
- 434.514 Lighting.
- 434.515 Receptacles.
- 434.516 Building exterior envelope.
- 434.517 HVAC systems and equipment.
- 434.518 Service water heating.
- 434.519 Controls.
- 434.520 Speculative buildings.
- 434.521 The simulation tool.

**Subpart F—Building Energy Compliance Alternative**

- 434.601 General.
- 434.602 Determination of the annual energy budget.
- 434.603 Determination of the design energy use.
- 434.604 Compliance.
- 434.605 Standard calculation procedure.
- 434.606 Simulation tool.
- 434.607 Life cycle cost analysis criteria.

**Subpart G—Reference Standards**

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

**§ 434.99 Explanation of numbering system for codes.**

(a) For purposes of this part, a derivative of two different numbering systems will be used.

(1) For the purpose of designating a section, the system employed in the Code of Federal Regulations (CFR) will be employed. The number “434” which signifies Part 434 in Chapter II of Title 10, Code of Federal Regulations, is used as a prefix for all section headings. The suffix is a two or three digit section

number. For example the lighting section of the standards is designated § 434.401.

(2) Within each section, a numbering system common to many national voluntary consensus standards is used. A decimal system is used to denote paragraphs and subparagraphs within a section. For example, in § 434.401, “401.2.1” refers to subsection 401, paragraph 2, subparagraph 1.

(b) The hybrid numbering system is used for two purposes:

(1) The use of the Code of Federal Regulation’s numbering system allows the researcher using the CFR easy access to the standards.

(2) The use of the second system allows the builder, designer, architect or engineer easy access because they are familiar to this system numbering. This system was chosen because of its commonality among the building industry.

**Subpart A—Administration and Enforcement—General****§ 434.100 Purpose.**

The provisions of this part provide minimum standards for energy efficiency for the design of new Federal commercial and multi-family high rise residential buildings. The performance standards are designed to achieve the maximum practicable improvements in energy efficiency and increases in the use of non-depletable sources of energy.

**§ 434.101 Scope.**

101.1 This part provides design requirements for the building envelope, electrical distribution systems and equipment for electric power, lighting, heating, ventilating, air conditioning, service water heating and energy management. It applies to new Federal multi-family high rise residential buildings and new Federal commercial buildings. The following are not covered:

101.1.1 Buildings, or portions thereof separated from the remainder of the building, that have a peak energy usage for space conditioning, service water heating, and lighting of less than 3.5 Btu/(h•ft<sup>2</sup>) of gross floor area.

101.1.2 Buildings of less than 100 square feet of gross floor area.

101.1.3 Heating, cooling, ventilating, or service hot water requirements for those spaces where processes occur for purposes other than occupant comfort and sanitation, and which impose thermal loads in excess of 5% of the loads that would otherwise be required for occupant comfort and sanitation without the process;

101.1.4 Envelope requirements for those spaces where heating or cooling

requirements are excepted in subsection 101.1.3 of this section.

101.1.5 Lighting for tasks not listed or encompassed by areas or activities listed in Table 514.1.1.

101.1.6 Buildings that are composed entirely of spaces listed in subsections 101.1.1 and 101.1.3.

101.2 A Federal agency may use this section to include any additions, renovations, repairs, replacements, and/or remodeling in the scope of the code and reference existing procedures in their building or administrative code to cover this application.

**§ 434.102 Compliance.**

102.1 A covered building must be designed and constructed consistent with the provisions of this part.

102.2 Buildings designed and constructed to meet the alternative requirements of subparts E or F shall be deemed to satisfy the requirements of this part. Such designs shall be certified by a registered architect or engineer stating that the estimated energy cost or energy use for the building as designed is no greater than the energy cost or energy use of a prototype building or reference building as determined pursuant to subparts E or F of this part.

**§ 434.103 Referenced standards (RS).**

103.1 The standards, technical handbooks, papers and regulations listed in § 434.701, shall be considered part of this part to the prescribed extent of such reference. Where differences occur between the provisions of this part and referenced standards, the provisions of this part shall apply. Whenever a reference is made in this part to an RS standard it refers to the standards listed in § 434.701.

**§ 434.105 Materials and equipment.**

105.1 Building materials and equipment shall be identified in designs in a manner that will allow for a determination of their compliance with the applicable provisions of this part.

**Subpart B—Definitions****§ 434.201 Definitions.**

For the purposes of this part, the following terms, phrases, and words shall be defined as provided:

*Accessible* (as applied to equipment): Admitting close approach; not guarded by locked doors, elevations, or other effective means. (See also “readily accessible”)

*Annual Fuel Utilization Efficiency (AFUE)*: The ratio of annual output energy to annual input energy that includes any non-heating season pilot input loss.

**Area of the space (A):** The horizontal lighted area of a given space measured from the inside of the perimeter walls or partitions, at the height of the working surface.

**Automatic:** Self-acting, operating by its own mechanism when actuated by some impersonal influence, such as a change in current strength, pressure, temperature, or mechanical configuration. (See also "manual")

**Automatic flue damper device:** An electrically operated device, in the flue outlet or in the inlet of or upstream of the draft hood of an individual automatically operated gas-fired appliance, which is designed to automatically open the flue outlet during appliance operation and to automatically close off the flue outlet when the appliance is in a standby condition.

**Automatic vent damper device:** A device intended for installation in the venting system, in the outlet of or downstream of the appliance draft hood, of an individual automatically operated gas-fired appliance, which is designed to automatically open the venting system when the appliance is in operation and to automatically close off the venting system when the appliance is in a standby or shutdown condition.

(1) **Electrically operated:** an automatic vent damper device that employs electrical energy to control the device.

(2) **Thermally actuated:** an automatic vent damper device dependent for operation exclusively upon the direct conversion of the thermal energy of the vent gases into mechanical energy.

**Boiler capacity:** The rated heat output of the boiler, in Btu/h, at the design inlet and outlet conditions and rated fuel or energy input.

**Building Code:** means a 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 that enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from unconditioned spaces.

**Check metering:** Measurement instrumentation for the supplementary monitoring of energy consumption (electric, gas, oil, etc) to isolate the various categories of energy use to permit conservation and control, in addition to the revenue metering furnished by the utility.

**Coefficient of performance (COP)—Cooling:** The ratio of the rate of heat removal to the rate of energy input, in

consistent units, for a complete cooling system or factory assembled equipment, as tested under a nationally recognized standard or designated operating conditions.

**Coefficient of performance (COP), heat pump—Heating:** The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system under designated operating conditions.

**Commercial building:** A building other than a residential building, including any building developed for industrial or public purposes. Including but not limited to occupancies for assembly, business, education, institutions, food sales and service, merchants, and storage.

**Conditioned floor area:** The area of the conditioned space measured at floor level from the interior surfaces of the walls.

**Conditioned space:** A cooled space, heated space, or indirectly conditioned space.

**Cooled space:** An enclosed space within a building that is cooled by a cooling system whose sensible capacity:

(1) Exceeds 5 Btu/(h•ft<sup>2</sup>); or

(2) Is capable of maintaining a space dry bulb temperature of 90°F or less at design cooling conditions.

**Daylight sensing control (DS):** A device that automatically regulates the power input to electric lighting near the fenestration to maintain the desired workplace illumination, thus taking advantage of direct or indirect sunlight.

**Daylighted space:** The space bounded by vertical planes rising from the boundaries of the daylighted area on the floor to the floor or roof above.

**Daylighted zone:**

(1) Under skylights: the area under each skylight whose horizontal dimension in each direction is equal to the skylight dimension in that direction plus either the floor-to-ceiling height or the dimension to an opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least.

(2) At vertical glazing: the area adjacent to vertical glazing that receives daylighting from the glazing. For purposes of this definition and unless more detailed daylighting analysis is provided, the daylighting zone depth is assumed to extend into the space a distance of 15 ft or to the nearest opaque partition, whichever is less. The daylighting zone width is assumed to be the width of the window plus either 2 ft on each side, the distance to an opaque partition, or one half the distance to an adjacent skylight or vertical glazing, whichever is least.

**Dead band (dead zone):** The range of values within which an input variable that can be varied without initiating any noticeable change in the output variable.

**Degree-day, cooling:** A unit, based upon temperature difference and time, used in estimating cooling energy consumption. For any one day, when the mean temperature is more than a reference temperature, typically 65°F, there are as many degree-days as degrees Fahrenheit temperature difference between the mean temperature for the day and the reference temperature. Annual cooling degree-days (CDD) are the sum of the degree-days over a calendar year.

**Degree-day, heating:** A unit, based upon temperature difference and time, used in estimating heating energy consumption. For any one day, when the mean temperature is less than a reference temperature, typically 65°F, there are as many degree-days as degrees Fahrenheit temperature difference between the mean temperature for the day and the reference temperature. Annual heating degree days (HDD) are the sum of the degree-days over a calendar year.

**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.

**Economizer, air:** A ducting arrangement and automatic control system that allows a cooling supply fan system to supply outdoor (outside) air to reduce or eliminate the need for mechanical refrigeration during mild or cold weather.

**Economizer, water:** A system by which the supply air of a cooling system is cooled directly or indirectly or both by evaporation of water or by other appropriate fluid in order to reduce or eliminate the need for mechanical refrigeration.

**Efficiency, HVAC system:** The ratio of the useful energy output, at the point of use to the energy input in consistent units, for a designated time period, expressed in percent.

**Emergency system (back-up system):** A system that exists for the purpose of operating in the event of failure of a primary system. Emergency use: Electrical and lighting systems required to supply power automatically for illumination and equipment in the event of a failure of the normal power supply.

**Energy efficiency ratio (EER):** The ratio of net equipment cooling capacity in Btu/h to total rate of electric input in

watts under designated operating conditions. When consistent units are used, this ratio becomes equal to COP. (See also "coefficient of performance".)

**Fan system energy demand:** The sum of the demand of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the conditioned space(s) and return it back to the source or exhaust it to the outdoors.

**Federal Agency:** Means 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 Building:** Means any building to be constructed by, or for the use of, any Federal Agency which is not legally subject to State or local building codes or similar requirements.

**Fenestration:** Any light-transmitting section in a building wall or roof. The fenestration includes glazing material (which may be glass or plastic), framing (mullions, muntins, and dividers), external shading devices, internal shading devices, and integral (between glass) shading devices.

**Fenestration area:** The total area of fenestration measured using the rough opening and including the glass or plastic, sash, and frame.

**Flue damper:** A device, in the flue outlet or in the inlet of or upstream of the draft hood of an individual automatically operated gas-fired appliance, which is designed to automatically open the flue outlet during appliance operation and to automatically close off the flue outlet when the appliance is in a standby condition.

**Gross floor area:** The sum of the floor areas of the conditioned spaces within the building, including basements, mezzanine and intermediate-floor tiers, and penthouses of headroom height 7.5 ft or greater. It is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings (excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features).

**Gross lighted area (GLA):** The sum of the total lighted areas of a building measured from the inside of the perimeter walls for each floor of the building.

**Heat capacity (HC):** The amount of heat necessary to raise the temperature of a given mass 1°F. Numerically, the mass expressed per unit of wall surface

multiplied by the specific heat Btu/(ft<sup>2</sup>•°F).

**Heat trap:** Device or piping arrangement that effectively restricts the natural tendency of hot water to rise in vertical pipes during standby periods. Examples are the U-shaped arrangement of elbows or a 360-degree loop of tubing.

**Heated space:** An enclosed space within a building that is heated by a heating system whose output capacity

- (1) Exceeds 10 Btu/(h•ft<sup>2</sup>), or
- (2) Is capable of maintaining a space dry-bulb temperature of 50°F or more at design heating conditions.

**Heating seasonal performance factor (HSPF):** The total heating output of a heat pump during its normal annual usage period for heating, in Btu, divided by the total electric energy input during the same period, in watt-hours.

**High rise residential building:** Hotels, motels, apartments, condominiums, dormitories, barracks, and other residential-type facilities that provide complete housekeeping or transient living quarters and are over three stories in height above grade.

**Humidistat:** An automatic control device responsive to changes in humidity.

**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.

**Indirectly conditioned space:** An enclosed space within the building that is not a heated or cooled space, whose area-weighted heat transfer coefficient to heated or cooled spaces exceeds that to the outdoors or to unconditioned spaces; or through which air from heated or cooled spaces is transferred at a rate exceeding three air changes per hour. (See also "heated space", "cooled space", and "unconditioned space".)

**Infiltration:** The uncontrolled inward air leakage through cracks and crevices in any building element and around windows and doors of a building.

**Integrated part-load value (IPLV):** A single-number figure of merit based on part-load EER or COP expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

**Lumen maintenance control:** A device that senses the illumination level and causes an increase or decrease of illuminance to maintain a preset illumination level.

**Manual:** Action requiring personal intervention for its control. As applied to an electric controller, manual control does not necessarily imply a manual controller but only that personal

intervention is necessary. (See automatic.)

**Marked rating:** The design load operating conditions of a device as shown by the manufacturer on the nameplate or otherwise marked on the device.

**Multi-family high rise residential:** A residential building containing three or more dwelling units and is designed to be 3 or more stories above grade.

**Occupancy sensor:** A device that detects the presence or absence of people within an area and causes any combination of lighting, equipment, or appliances to be adjusted accordingly.

**Opaque areas:** All exposed areas of a building envelope that enclose conditioned space except fenestration areas and building service openings such as vents and grilles.

**Orientation:** The directional placement of a building on a building site with reference to the building's longest horizontal axis or, if there is no longest horizontal axis, then with reference to the designated main entrance.

**Outdoor air:** Air taken from the exterior of the building that has not been previously circulated through the building. (See "ventilation air".)

**Ozone depletion factor:** A relative measure of the potency of chemicals in depleting stratospheric ozone. The ozone depletion factor potential depends upon the chlorine and the bromine content and atmospheric lifetime of the chemical. The depletion factor potential is normalized such that the factor for CFC-11 is set equal to unity and the factors for the other chemicals indicate their potential relative to CFC-11.

**Packaged terminal air conditioner (PTAC):** 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 PTAC capable of using the refrigeration system in a reverse cycle or heat pump mode to provide heat.

**Plenum:** An enclosure that is part of the air-handling system and is distinguished by having a very low air velocity. A plenum often is formed in part or in total by portions of the building.

**Private driveways, walkways, and parking lots:** Exterior transit areas that are associated with a commercial or residential building and intended for use solely by the employees or tenants and not by the general public.



**Process energy:** Energy consumed in support of a manufacturing, industrial, or commercial process other than the maintenance of comfort and amenities for the occupants of a building.

**Process load:** The calculated or measured time-integrated load on a building resulting from the consumption or release of process energy.

**Programmable:** Capable of being preset to certain conditions and having self-initiation to change to those conditions.

**Projection factor:** The exterior horizontal shading projection depth divided by the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the external shading projection in units consistent with the projection depth.

**Prototype building:** A generic building design of the same size and occupancy type as the proposed design that complies with the prescriptive requirements of Subpart D and has prescribed assumptions used to generate the energy budget concerning shape, orientation, and HVAC and other system designs.

**Public driveways, walkways, and parking lots:** Exterior transit areas that are intended for use by the general public.

**Public facility restroom:** A restroom used by the transient public.

**Readily accessible:** Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See also accessible.)

**Recooling:** Lowering the temperature of air that has been previously heated by a heating system.

**Reference building:** A specific building design that has the same form, orientation, and basic systems as the prospective design that is to be evaluated for compliance and meets all the criteria listed in subsection 501.2 or subsection 601.2.

**Reheating:** Raising the temperature of air that has been previously cooled either by refrigeration or an economizer system.

**Reset:** Adjustment of the controller setpoint to a higher or lower value automatically or manually.

**Roof:** Those portions of the building envelope, including all opaque surfaces, fenestration, doors, and hatches, that are above conditioned space and are horizontal or tilted at less than 60° from horizontal. (See also "walls")

**Room air conditioner:** An encased assembly designed as a unit to be mounted in a window or through a wall

or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room, or zone. It includes a prime source of refrigeration for cooling and dehumidification and means for circulating and cleaning air and may also include means for ventilating and heating.

**Seasonal energy efficiency ratio (SEER):** The total cooling output of an air conditioner during its normal annual usage period for cooling, in Btu, divided by the total electric energy input during the same period, in watt-hours.

**Service systems:** All energy-using or energy-distributing components in a building that are operated to support the occupant or process functions housed therein (including HVAC, service water heating, illumination, transportation, cooking or food preparation, laundering, or similar functions).

**Service water heating:** The supply of hot water for purposes other than comfort heating and process requirements.

**Shading coefficient (SC):** The ratio of solar heat gain through fenestration, with or without integral shading devices, to that occurring through unshaded 1/8-in-thick clear double-strength glass.

**Shell Building:** A building for which the envelope is designed, constructed, or both prior to knowing the occupancy type. (See also "speculative building")

**Single-Line Diagram:** A simplified schematic drawing that shows the connection between two or more items. Common multiple connections are shown as one line.

**Skylight:** Glazing that is horizontal or tilted less than 60° from horizontal.

**Solar energy source:** Natural daylighting or thermal, chemical, or electrical energy derived from direct conversion of incident solar radiation at the building site.

**Speculative building:** A building for which the envelope is designed, constructed, or both prior to the design of the lighting, HVAC systems, or both. A speculative building differs from a shell building in that the intended occupancy is known for the speculative building. (See also "shell building")

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

**Tandem wiring:** Pairs of luminaires operating with lamps in each luminaire powered from a single ballast contained in one of the luminaires.

**Task lighting:** Lighting that provides illumination for specific functions and is directed to a specific surface or area.

**Task location:** An area of the space where significant visual functions are performed and where lighting is required above and beyond that required for general ambient use.

**Terminal element:** A device by which the transformed energy from a system is finally delivered. Examples include registers, diffusers, lighting fixtures, and faucets.

**Terminal conductance (C):** The constant time rate of heat flow through the unit area of a body induced by a unit temperature difference between the surfaces, expressed in Btu/(h•ft<sup>2</sup>•°F). It is the reciprocal of thermal resistance. (See "thermal resistance")

**Thermal mass:** Materials with mass heat capacity and surface area capable of affecting building loads by storing and releasing heat as the interior or exterior temperature and radiant conditions fluctuate. (See also "heat capacity" and "wall heat capacity")

**Thermal mass wall insulation position:**

(1) Exterior insulation position: a wall having all or nearly all of its mass exposed to the room air with the insulation on the exterior of that mass.

(2) Integral insulation position: a wall having mass exposed to both room and outside (outside) air with substantially equal amounts of mass on the inside and outside of the insulation layer.

(3) Interior insulation position: a wall not meeting either of the above definitions, particularly a wall having most of its mass external to an insulation layer.

**Thermal resistance (R):** The reciprocal of thermal conductance 1/C, 1/H, 1/U; expressed in (h•ft<sup>2</sup>•°F)/Btu.

**Thermal transmittance (U):** The overall coefficient of heat transfer from air to air. It is the time rate of heat flow per unit area under steady conditions from the fluid on the warm side of the barrier to the fluid on the cold side, per unit temperature difference between the two fluids, expressed in Btu/(h•ft<sup>2</sup>•°F).

**Thermal transmittance, overall (U<sub>o</sub>):** The gross overall (area weighted average) coefficient of heat transfer from air to air for a gross area of the building envelope, Btu/(h•ft<sup>2</sup>•°F). The U<sub>o</sub> value applies to the combined effect of the time rate of heat flows through the various parallel paths, such as windows, doors, and opaque construction areas, composing the gross area of one or more building envelope components, such as walls, floors, and roof or ceiling.

**Thermostat:** An automatic control device responsive to temperature.



**Unconditioned space:** Space within a building that is not a conditioned space. (See "conditioned space")

**Unitary cooling equipment:** One or more factory-made assemblies that normally include an evaporator or cooling coil, a compressor, and a condenser combination (and may also include a heating function).

**Unitary heat pump:** One or more factory-made assemblies that normally include an indoor conditioning coil, compressor(s), and outdoor coil or refrigerant-to-water heater exchanger, including means to provide both heating and cooling functions.

**Variable-air-volume (VAV) HVAC system:** HVAC systems that control the dry-bulb temperature within a space by varying the volume of heated or cooled supply air to the space.

**Vent damper:** A device intended for installation in the venting system, in the outlet of or downstream of the appliance draft hood, of an individual automatically operating gas-fired appliance, which is designed to automatically open the venting system

when the appliance is in operation and to automatically close off the venting system when the appliance is in a standby or shutdown condition.

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

**Ventilation air:** That portion of supply air which comes from the outside, plus any recirculated air, to maintain the desired quality of air within a designated space. (See also "outdoor air")

**Visible light transmittance (VLT):** The fraction of solar radiation in the visible light spectrum that passes through the fenestration (window, clerestory, or skylight).

**Walls:** Those portions of the building envelope enclosing conditioned space, including all opaque surfaces, fenestration, and doors, which are vertical or tilted at an angle of 60° from horizontal or greater. (See also "roof")

**Wall heat capacity:** The sum of the products of the mass of each individual

material in the wall per unit area of wall surface times its individual specific heat, expressed in Btu/(ft<sup>2</sup>•°F). (See "thermal mass")

**Window to wall ratio (WWR):** The ratio of the wall fenestration area to the gross exterior wall area.

**Zone:** A space or group of spaces within a building with any combination of heating, cooling, or lighting requirements sufficiently similar so that desired conditions can be maintained throughout by a single controlling device.

## Subpart C—Design Conditions

### § 434.301 Design criteria.

301.1 The following design parameters shall be used for calculations required under subpart D of this part.

#### 301.1.1 Exterior Design Conditions.

Exterior Design Conditions shall be expressed in accordance with Table 301.1.

TABLE 301.1.—Exterior Design Conditions

Winter Design Dry-Bulb (99%) .....	Degrees F.
Summer Design Dry-Bulb (2.5%) .....	Degrees F.
Mean Coincident Wet-Bulb (2.5%) .....	Degrees F.
Degree-Days, Heating (Base 65) .....	HDD Base 65 °F.
Degree-Days, Cooling (Base 65) .....	CDD Base 65 °F.
Annual Operating Hours, 8 a.m. to 4 p.m. when 55° ≤ T ≤ 69°F .....	Hours.

[The exterior design conditions shall be added to Table 301.1 from the city-specific Shading Coefficient table from the Example Alternate Component Package Table. Copies of specific tables contained in Appendix A can be obtained from the Energy Code for Federal Commercial Buildings, Docket No. EE-RM-79-112-C, Buildings Division, EE-432, Office of Codes and Standards, U.S. Department of Energy, Room 1J-018, 1000 Independence Avenue, S.W., Washington, D.C. 20585, (202) 586-0517. Adjustments may be made to reflect local climates which differ from the tabulated temperatures or local weather experience as determined by the building official. Where local building site climatic data are not available, climate data from a nearby location included in RS-1, Appendix C, and RS-4 Chapter 24, Table 1, shall be used as determined by the building official.]

301.2 **Indoor Design Conditions.** Indoor design temperature and humidity conditions shall be in accordance with the comfort criteria in RS-2, except that humidification and dehumidification are not required.

## Subpart D—Building Design Requirements—Electric Systems and Equipment

### § 434.401 Electrical power and lighting systems.

Electrical power and lighting systems, other than those systems or portions thereof required for emergency use only, shall meet these requirements.

#### 401.1 Electrical Distribution Systems.

401.1.1 Check Metering. Single-tenant buildings with a service over 250 kVA and tenant spaces with a connected load over 100 kVA in multiple-tenant buildings shall have provisions for check metering of electrical

consumption. The electrical power feeders for which provision for check metering is required shall be subdivided as follows:

401.1.1.1 Lighting and receptacle outlets

401.1.1.2 HVAC systems and equipment

401.1.1.3 Service water heating (SWH), elevators, and special occupant equipment or systems of more than 20 kW.

401.1.1.4 Exception to 401.1.1.1 through 401.1.1.3: 10 percent or less of the loads on a feeder may be from another usage or category.

401.1.2 Tenant-shared HVAC and service hot water systems in multiple tenant buildings shall have provision to be separately check metered.

401.1.3 Subdivided feeders shall contain provisions for portable or permanent check metering. The minimum acceptable arrangement for

compliance shall provide a safe method for access by qualified persons to the enclosures through which feeder conductors pass and provide sufficient space to attach clamp-on or split core current transformers. These enclosures may be separate compartments or combined spaces with electrical cabinets serving another function. Dedicated enclosures so furnished shall be identified as to measuring function available.

401.1.4 Electrical Schematic. The person responsible for installing the electrical distribution system shall provide the Federal building manager a single-line diagram of the record drawing for the electrical distribution system, which includes the location of check metering access, schematic diagrams of non-HVAC electrical control systems, and electrical equipment manufacturer's operating and maintenance literature.

401.2 Electric Motors. All permanently wired polyphase motors of 1 hp or more shall meet these requirements:

401.2.1 Efficiency. National Electrical Manufacturers Association (NEMA) design A & B squirrel-cage, foot-mounted, T-frame induction motors

having synchronous speeds of 3600, 1800, 1200, and 900 rpm, expected to operate more than 1000 hours per year shall have a nominal full-load efficiency no less than that shown in Table 401.2.1 or shall be classified as an "energy efficient motor" in accordance with RS-3. The following are not covered:

(a) Multispeed motors used in systems designed to use more than one speed.

(b) Motors used as a component of the equipment meeting the minimum equipment efficiency requirements of subsection 403, provided that the motor input is included when determining the equipment efficiency.

Table 401.2.1.—MINIMUM ACCEPTABLE NOMINAL FULL-LOAD EFFICIENCY FOR SINGLE-SPEED POLYPHASE SQUIRREL-CAGE INDUCTION MOTORS HAVING SYNCHRONOUS SPEEDS OF 3600, 1800, 1200 AND 900 RPM <sup>1</sup>

HP	2-Pole		4-Pole		6-Pole		8-Pole	
	Nominal efficiency	Minimum efficiency	Nominal efficiency	Minimum efficiency	Nominal efficiency	Minimum efficiency	Nominal efficiency	Minimum efficiency
<b>Full-Load Efficiencies—Open Motors</b>								
1.0 .....	82.5	81.5	82.5	81.5	80.0	78.5	74.0	72.0
1.5 .....	84.0	82.5	84.0	82.5	84.0	82.5	75.5	74.0
2.0 .....	84.0	82.5	86.5	85.5	86.5	85.5	86.5	85.5
3.0 .....	85.5	84.0	87.5	86.5	87.5	86.5	87.5	86.0
5.0 .....	87.5	86.5	88.5	87.5	88.5	87.5	88.5	87.5
7.5 .....	88.5	87.5	89.5	88.5	90.2	89.5	89.5	88.5
10.0 .....	89.5	88.5	91.0	90.2	90.2	89.5	89.5	88.5
15.0 .....	90.2	89.5	91.0	90.2	91.0	90.2	90.2	89.5
20.0 .....	91.0	90.2	91.7	91.0	91.7	91.0	90.2	89.5
25.0 .....	91.0	90.2	92.4	91.7	92.4	91.7	91.7	90.2
30.0 .....	91.7	91.0	93.0	92.4	93.0	92.4	91.0	90.2
40.0 .....	92.4	91.7	93.0	92.4	93.0	92.4	91.7	91.0
50.0 .....	93.0	92.4	93.6	93.0	93.6	93.0	92.4	91.7
60.0 .....	93.0	92.4	94.1	93.6	93.6	93.0	93.6	93.0
75.0 .....	93.0	92.4	94.1	93.6	94.1	93.6	93.6	93.0
100.0 .....	93.6	93.0	94.5	94.1	94.1	93.6	93.6	93.0
125.0 .....	93.6	93.0	95.0	94.5	94.5	94.1	93.6	93.0
150.0 .....	94.5	94.1	95.0	94.5	94.5	94.1	93.6	93.0
200.0 .....								
<b>Full-Load Efficiencies—Enclosed Motors</b>								
1.0 .....	75.5	74.5	82.5	81.5	80.0	78.5	74.0	72.0
1.5 .....	82.5	81.5	84.0	82.5	85.5	84.0	77.0	75.5
2.0 .....	84.0	82.5	84.5	82.5	86.5	85.5	82.5	81.5
3.0 .....	85.5	84.0	87.5	86.5	87.5	86.5	84.0	82.5
5.0 .....	87.5	86.5	87.5	86.5	87.5	86.5	85.5	84.0
7.5 .....	88.5	87.5	89.5	88.5	89.5	88.5	85.5	84.0
10.0 .....	89.5	88.5	89.5	88.5	89.5	88.5	88.5	87.5
15.0 .....	90.2	89.5	91.0	90.2	90.2	89.5	88.5	87.5
20.0 .....	90.2	89.5	91.0	90.2	90.2	89.5	89.5	88.5
25.0 .....	91.0	90.2	92.4	91.7	91.7	91.0	89.5	88.5
30.0 .....	91.0	90.2	92.4	91.7	91.7	91.0	91.0	90.2
40.0 .....	91.7	91.0	93.0	92.4	93.0	92.4	91.0	90.2
50.0 .....	92.4	91.7	93.0	92.4	93.0	92.4	91.7	91.0
60.0 .....	93.0	92.4	93.6	93.0	93.6	93.0	91.7	91.0
75.0 .....	93.0	92.4	94.1	93.6	93.6	93.0	93.0	92.4
100.0 .....	93.6	93.0	94.5	94.1	94.1	93.6	93.0	92.4
125.0 .....	94.5	94.1	94.5	94.1	94.1	93.6	93.6	93.0
150.0 .....	94.5	94.1	95.0	94.5	94.5	94.1	94.1	93.0
200.0 .....	95.0	94.5	95.0	94.5	95.0	94.5	94.1	93.6

<sup>1</sup> For many applications, efficiencies greater than those listed are likely to be cost-effective. Guidance for evaluating the cost effectiveness of energy efficient motor applications is given in RS-43 and RS-44.

401.3 Lighting Power Allowance. The lighting system shall meet the provisions of subsections 401.3.1 through 401.3.5. As an alternative to subsections 401.3.1 and 401.3.2, the Lighting Compliance Calculation Computer Program (LTGSTD21) found in ASHRAE/IES Standard 90.1-1989 for the building or facility may be used to determine the lighting power for the building or facility.

401.3.1 Building Exterior. The total connected exterior lighting power for the building, or a facility containing multiple buildings, shall not exceed the total exterior lighting power allowance, which is the sum of the individual allowances determined from Table 401.3.1. The individual allowances are determined by multiplying the specific area or length of each area description times the allowance for that area. Exceptions are as follows: Lighting for outdoor manufacturing or processing facilities, commercial greenhouses, outdoor athletic facilities, public monuments, designated high-risk security areas, signs, retail storefronts, exterior enclosed display windows, and lighting specifically required by local ordinances and regulations.

TABLE 401.3.1—Exterior Lighting Power Allowance

Area Description	Allowance
Exit (with or without canopy) .....	25 W/lin ft of door opening.
Entrance (without canopy) .....	30 W/lin ft of door opening.
Entrance (with canopy):	
High Traffic (retail, hotel, airport, theater, etc.) .....	10 W/ft <sup>2</sup> of canopied area.
Light Traffic (hospital, office, school, etc.) .....	4 W/ft <sup>2</sup> of canopied area.
Loading area .....	0.40 W/ft <sup>2</sup> .
Loading door .....	20 W/lin ft <sup>2</sup> of door opening.
Building exterior surfaces/facades .....	0.25 W/ft <sup>2</sup> of surface area to be illuminated.
Storage and non-manufacturing work areas .....	0.20 W/ft <sup>2</sup> .
Other activity areas for casual use such as picnic grounds, gardens, parks, and other landscaped areas .....	0.10 W/ft <sup>2</sup> .
Private driveways/walkways .....	0.10 W/ft <sup>2</sup> .
Public driveways/walkways .....	0.15 W/ft <sup>2</sup> .
Private parking lots .....	0.12 W/ft <sup>2</sup> .
Public parking lots .....	0.18 W/ft <sup>2</sup> .

401.3.1.1 Trade-offs of exterior lighting budgets among exterior areas shall be allowed provided the total connected lighting power of the exterior area does not exceed the exterior lighting power allowance. Trade-offs between interior lighting power allowances and exterior lighting power allowances shall not be allowed.

401.3.2 Building interiors. The total connected interior lighting power for a building, including adjustments in accordance with subsection 401.3.3, shall not exceed the total interior lighting power allowance explained in this paragraph. Using Table 401.3.2a, multiply the interior lighting power allowance value by the gross lighted area of the most appropriate building or space activity. For multi-use buildings, using Table 401.3.2a, select the interior power allowance value for each activity using the column for the gross lighted area of the whole building and multiply it by the associated gross area for that activity. The interior lighting power allowance is the sum of all the wattages for each area/activity. Using Table 401.3.2b, c, or d, multiply the interior lighting power allowance values of each individual area/activity by the area of the space and by the area factor from Figure 401.3.2e, based on the most appropriate area/activity provided. The interior lighting power allowance is the sum of the wattages for each individual space. Use the Lighting Compliance Calculation Computer Program (LTGSTD21) of RS-1. When over 20% of the building's tasks or interior areas are undefined, the most appropriate value for that building from Table 401.3.2a shall be used for the undefined spaces. Exceptions are as follows:

(a) Lighting power that is an essential technical element for the function performed in theatrical, stage, broadcasting, and similar uses.

(b) Specialized medical, dental, and research lighting.

(c) Display lighting for exhibits in galleries, museums, and monuments.

(d) Lighting solely for indoor plant growth (between the hours of 10:00pm and 6:00am).

(e) Emergency lighting that is automatically off during normal building operation.

(f) High-risk security areas.

(g) Spaces specifically designed for the primary use by the physically impaired or aged.

(h) Lighting in dwelling units.

401.3.2.1 Trade-offs of the interior lighting power budgets among interior spaces shall be allowed provided the total connected lighting power within the building does not exceed the interior lighting power allowance. Trade-offs between interior lighting power allowances and exterior lighting power allowances shall not be allowed.

401.3.2.2 Building/Space Activities. Definitions of buildings/space activity as they apply to Table 401.3.2a are as follows. These definitions are necessary to characterize the activities for which lighting is provided. They are applicable only to Table 401.3.2a. They are not intended to be used elsewhere in place of building use group definitions provided in the Building Code. They are not included in § 434.200, "Definitions," to avoid confusion with "Occupancy Type Categories."

**Food service, fast food, and cafeteria:** This group includes cafeterias, hamburger and sandwich stores, bakeries, ice cream parlors, cookie stores, and all other kinds of retail food service establishments in which customers are generally served at a counter and their direct selections are paid for and taken to a table or carried out.

**Garages:** This category includes all types of parking garages, except for service or repair areas.

**Leisure dining and bar:** This group includes cafes, diners, bars, lounges, and similar establishments where orders are placed with a wait person.

**Mall concourse, multi-store service:** This group includes the interior of multifunctional public spaces, such as shopping center malls, airports, resort concourses and malls, entertainment facilities, and related types of buildings or spaces.

**Offices:** This group includes all kinds of offices, including corporate and professional offices, office/laboratories, governmental offices, libraries, and similar facilities, where paperwork occurs.

**Retail:** A retail store, including departments for the sale of accessories, clothing, dry goods, electronics, and toys, and other types of establishments that display objects for direct selection and purchase by consumers. Direct selection means literally removing an item from display and carrying it to the checkout or pick-up at a customer service facility.

**Schools:** This category, subdivided by pre-school/elementary, junior high/high school, and technical/vocational, includes public and private educational institutions, for children or adults, and may also include community centers, college and university buildings, and business educational centers.

**Service establishment:** A retail-like facility, such as watch repair, real estate offices, auto and tire service facilities, parts departments, travel agencies and similar facilities, in which the customer obtains services rather than the direct selection of goods.

**Warehouse and storage:** This includes all types of support facilities, such as warehouses, barns, storage buildings,

shipping/receiving buildings, boiler or mechanical buildings, electric power buildings, and similar buildings where the primary visual task is large items.

#### 401.3.2.—TABLES AND FIGURES, TABLE 401.3.2a, INTERIOR LIGHTING POWER ALLOWANCE W/FT<sup>2</sup>

Building Space Activity <sup>1, 2</sup>	Gross lighted area of total building					
	0 to 2,000 ft <sup>2</sup>	2,001 to 10,000 ft <sup>2</sup>	10,001 to 25,000 ft <sup>2</sup>	25,001 to 50,000 ft <sup>2</sup>	50,001 to 250,000 ft <sup>2</sup>	>250,000 ft <sup>2</sup>
Food Service:						
Fast Food/Cafeteria .....	1.50	1.38	1.34	1.32	1.31	1.30
Leisure Dining/Bar .....	2.20	1.91	1.71	1.56	1.46	1.40
Offices .....	1.90	1.81	1.72	1.65	1.57	1.50
Retail <sup>3</sup> .....	3.30	3.08	2.83	2.50	2.28	2.10
Mall Concourse Multi-store Service .....	1.60	1.58	1.52	1.46	1.43	1.40
Service Establishment .....	2.70	2.37	2.08	1.92	1.80	1.70
Garages .....	0.30	0.28	0.24	0.22	0.21	0.20
Schools:						
Preschool/Elementary .....	1.80	1.80	1.72	1.65	1.57	1.50
Jr. High/High School .....	1.90	1.90	1.88	1.83	1.76	1.70
Technical/Vocational .....	2.40	2.33	2.17	2.01	1.84	1.70
Warehouse/Storage .....	0.80	0.66	0.56	0.48	0.43	0.40

<sup>1</sup> If at least 10% of the building area is intended for multiple space activities, such as parking, retail, and storage in an office building, then calculate for each separate building type/space activity.

<sup>2</sup> The values in the categories are building wide allowances which include the listed activity and directly related facilities such as conference rooms, lobbies, corridors, restrooms, etc.

<sup>3</sup> Includes general, merchandising, and display lighting.

TABLE 401.3.2b.—Unit Interior Lighting Power Allowance

Common area/activity	UPD W/ft <sup>2</sup>
Auditorium <sup>2</sup> .....	1.4
Corridor <sup>3</sup> .....	0.8
Classroom/Lecture Hall .....	2.0
Electrical/Mechanical Equipment Room:	
General <sup>3</sup> .....	0.7
Control Rooms <sup>3</sup> .....	1.5
Food Service:	
Fast Food/Cafeteria .....	1.3
Leisure Dining <sup>4</sup> .....	1.4
Bar/Lounge <sup>4</sup> .....	2.5
Kitchen .....	1.4
Recreation/Lounge .....	0.7
Stair:	
Active Traffic .....	0.6
Emergency Exit .....	0.4
Toilet and Washroom .....	0.8
Garage:	
Auto & Pedestrian Circulation Area .....	0.3
Parking Area .....	0.2
Laboratory .....	2.2
Library:	
Audio Visual .....	1.1
Stack Area .....	1.1
Card File & Cataloging .....	0.8
Reading Area .....	1.1
Lobby (General):	
Reception & Waiting .....	1.0
Elevator Lobbies .....	0.4
Atrium (Multi-Story):	
First 3 Floors .....	0.7
Each Additional Floor .....	0.2
Locker Room and Shower .....	0.8
<b>Office Category 1</b>	
Enclosed offices, all open plan offices w/o partitions or w/partitions <sup>6</sup> lower than 4.5 ft below the ceiling: <sup>5</sup>	
Reading, Typing and Filing .....	1.5
Drafting .....	1.9
Accounting .....	1.6
<b>Office Category 2</b>	
Open plan offices 900 ft <sup>2</sup> or larger w/partitions <sup>6</sup> 3.5 to 4.5 ft below the ceiling. Offices less than 900 ft <sup>2</sup> shall use category 1: <sup>3</sup>	
Reading, Typing and Filing .....	1.5
Drafting .....	2.0
Accounting .....	1.8

TABLE 401.3.2b.—Unit Interior Lighting Power Allowance—Continued

Common area/activity	UPD W/ft <sup>2</sup>
<b>Office Category 3</b>	
Open plan offices 900 ft <sup>2</sup> or larger w/partitions* higher than 3.5 ft below the ceiling. Offices less than 900 ft <sup>2</sup> shall use category 1: <sup>3</sup>	
Reading, Typing and Filing .....	1.7
Drafting .....	2.3
Accounting .....	1.9
Common Activity Areas:	
Conference/Meeting Room <sup>2</sup> .....	1.3
Computer/Office Equipment .....	1.1
Filing, Inactive .....	1.0
Mail Room .....	1.8
Shop (Non-Industrial):	
Machinery .....	2.5
Electrical/Electronic .....	2.5
Painting .....	1.6
Carpentry .....	2.3
Welding .....	1.2
Storage & Warehouse:	
Inactive Storage .....	0.2
Active Storage, Bulky .....	0.3
Active Storage, Fine .....	0.9
Material Handling .....	1.0
Unlisted Space .....	0.2

<sup>1</sup> Use a weighted average UPD in rooms with multiple simultaneous activities, weighted in proportion to the area served.

<sup>2</sup> A 1.5 power adjustment factor is applicable for multi-function spaces when a supplementary system having independent controls is installed that has installed power ≤33% of the adjusted lighting power for that space.

<sup>3</sup> Area factor of 1.0 shall be used for these spaces.

<sup>4</sup> UPD includes lighting power required for clean-up purposes.

<sup>5</sup> Area factor shall not exceed 1.55.

TABLE 401.3.2c.—UNIT INTERIOR LIGHTING POWER ALLOWANCE

Specific building area/activity <sup>1</sup>	UPD W/ft <sup>2</sup>
Airport, Bus and Rail Station:	
Baggage Area .....	0.8
Concourse/Main Thruway .....	0.9
Ticket Counter .....	2.0
Waiting & Lounge Area .....	0.8
Bank:	
Customer Area .....	1.0
Banking Activity Area .....	2.2
Barber & Beauty Parlor .....	1.6
Church, Synagogue, Chapel:	
Worship/Congregational .....	1.7
Preaching & Sermon/Choir .....	1.8
Dormitory:	
Bedroom .....	1.0
Bedroom w/Study .....	1.3
Study Hall .....	1.2
Fire & Police Department:	
Fire Engine Room .....	0.7
Jail Cell .....	0.8
Hospital/Nursing Home:	
Corridor <sup>5</sup> .....	1.3
Dental Suite/Examination/Treatment .....	1.6
Emergency .....	2.0
Laboratory .....	1.7
Lounge/Waiting Room .....	0.9
Medical Supplies .....	2.4
Nursery .....	1.6
Nurse Station .....	1.8
Occupational Therapy/Physical Therapy .....	1.4
Patient Room .....	1.2
Pharmacy .....	1.5
Radiology .....	1.8
Surgical & OB Suites .....	1.8
General Area .....	6.0
Operating Room .....	2.0
Recovery .....	2.0
Hotel/Conference Center:	
Banquet Room/Multipurpose <sup>2</sup> .....	1.7

TABLE 401.3.2c.—UNIT INTERIOR LIGHTING POWER ALLOWANCE—Continued

Specific building area/activity <sup>1</sup>	UPD W/ft <sup>2</sup>
Bathroom/Powder Room .....	1.2
Guest Room .....	0.9
Public Area .....	1.0
Exhibition Hall .....	1.8
Conference/Meeting <sup>3</sup> .....	1.5
Lobby .....	1.5
Reception Desk .....	2.4
Laundry:	
Washing .....	0.9
Ironing & Sorting .....	1.3
Museum & Gallery:	
General Exhibition .....	1.9
Inspection/Restoration .....	3.0
Storage (Artifacts):	
Inactive .....	0.6
Active .....	0.7
Post Office:	
Lobby .....	1.1
Sorting and Mailing .....	2.1
Service Station/Auto Repair .....	0.8
Theater:	
Performance Arts .....	1.3
Motion Picture .....	1.0
Lobby .....	1.3
<b>Retail Establishments—Merchandising and Circulation Area (Applicable to all lighting, including accent and display lighting, installed in merchandising and circulation areas)</b>	
Type 1: Jewelry merchandising, where minute examination of displayed merchandise is critical .....	5.6
Type 2: Fine merchandising, such as fine apparel and accessories, china, crystal, and silver art galleries and where the detailed display and examination of merchandising is important .....	2.9
Type 3: Mass merchandising, such as general apparel, variety goods, stationary, books, sporting goods, hobby materials, cameras, gifts, and luggage, displayed in a warehouse type of building, where focused display and detailed examination of merchandise is important .....	2.7
Type 4: General merchandising, such as general apparel, variety goods, stationary, books, sporting goods, hobby materials, cameras, gifts, and luggage, displayed in a department store type of building, where general display and examination of merchandise is adequate .....	2.3
Type 5: Food and miscellaneous such as bakeries, hardware and housewares, grocery stores, appliance and furniture stores, where pleasant appearance is important .....	
Type 6: Service establishments, where functional performance is important .....	2.4
Mall Concourse	
Retail Support Areas	
Tailoring	2.6
Dressing/Fitting Rooms	1.4
	2.1
	1.1

<sup>1</sup> Use a weighted average UPD in rooms with multiple simultaneous activities, weighted in proportion to the area served.

<sup>2</sup> A 1.5 power adjustment factor is applicable for multi-function spaces when a supplementary system having independent controls is installed that has installed power 33% of the adjusted lighting power for that space.

<sup>3</sup> Area factor or 1.0 shall be used for these spaces.

<sup>4</sup> UPD includes lighting power required for clean-up purpose.

<sup>5</sup> Area factor shall not exceed 1.55.

<sup>6</sup> Not less than 90 percent of all work stations shall be individually enclosed with partitions of at least the height described.

TABLE 401.3.2d.—UNIT INTERIOR LIGHTING POWER ALLOWANCE

Indoor athletic area/activity <sup>3, 6</sup>	UPD W/ft <sup>2</sup>
Seating Area, All Sports .....	0.4
Badminton:	
Club .....	0.5
Tournament .....	0.8
Basketball/Volleyball:	
Intramural .....	0.8
College .....	1.3
Professional .....	1.9
Bowling:	
Approach Area .....	0.5
Lanes .....	1.1
Boxing or Wrestling (platform):	
Amateur .....	2.4

TABLE 401.3.2d.—UNIT INTERIOR LIGHTING POWER ALLOWANCE—Continued

Indoor athletic area/activity <sup>3, 6</sup>	UPD W/ft <sup>2</sup>
Professional .....	4.8
Gymnasium:	
General Exercising and Recreation Only .....	1.0
Handball/Racquetball/Squash:	
Club .....	1.3
Tournament .....	2.6
Hockey, Ice:	
Amateur .....	1.3
College or Professional .....	2.6
Skating Rink:	
Recreational .....	0.6
Exhibition/Professional .....	2.6
Swimming:	
Recreational .....	0.9
Exhibition .....	1.5
Underwater .....	1.0
Tennis:	
Recreational (Class III) .....	1.3
Club/College (Class II) .....	1.9
Professional (Class I) .....	2.6
Tennis, Table:	
Club .....	1.0
Tournament .....	1.6

<sup>1</sup> Use a weighted average UPD in rooms with multiple simultaneous activities, weighted in proportion to the area served.

<sup>2</sup> A 1.5 power adjustment factor is applicable for multi-function spaces when a supplementary system having independent controls is installed that has installed power ≤33% of the adjusted lighting power for that space.

<sup>3</sup> Area factor of 1.0 shall be used for these spaces.

<sup>4</sup> UPD includes lighting power required for clean-up purpose.

<sup>5</sup> Area factor shall not exceed 1.55.

<sup>6</sup> Consider as 10 ft. beyond playing boundaries but less than or equal to the total floor area of the sports space minus spectator seating area.

**Figure 401.3.2e**  
**Area Factor Formula**

$$\text{where } n = \frac{10.21 (CH - 2.5)}{\sqrt{A_r}} - 1$$

**Area Factor****Formula:**

Area

Factor (AF) =  $0.2 + 0.8 (1/0.9^n)$ **where:**

AF = area factor,

CH = ceiling height (ft),

 $A_r$  = space area (ft<sup>2</sup>).

If AF &lt; 1.0 use 1.0; if AF &gt; 1.8 use 1.8

**Billing Code 6450-01-C**

401.3.3 Lighting Power Control Credits. The interior connected lighting power determined in accordance with § 434.401.3.2 can be decreased for luminaries that are automatically controlled for occupancy, daylight, lumen maintenance, or programmable timing. The adjusted interior connected lighting power shall be determined by subtracting the sum of all lighting power control credits from the interior connected lighting power. Using Table 401.3.3, the lighting power control credit equals the power adjustment factor times the connected lighting

power of the controlled lighting. The lighting power adjustment shall be applied with the following limitations:

(a) It is limited to the specific area controlled by the automatic control device.

(b) Only one lighting power adjustment may be used for each building space or luminaire, and 50 percent or more of the controlled luminaire shall be within the applicable space.

(c) Controls shall be installed in series with the lights and in series with all manual switching devices.

(d) When sufficient daylight is available, daylight sensing controls shall

be capable of reducing electrical power consumption for lighting (continuously or in steps) to 50 percent or less of maximum power consumption.

(e) Daylight sensing controls shall control all luminaires to which the adjustment is applied and that direct a minimum of 50 percent of their light output into the daylight zone.

(f) Programmable timing controls shall be able to program different schedules for occupied and unoccupied days, be readily accessible for temporary override with automatic return to the original schedule, and keep time during power outages for at least four hours.

TABLE 401.3.3.—LIGHTING POWER ADJUSTMENT FACTORS

Automatic control devices	PAF
(1) Daylight Sensing controls (DS), continuous dimming .....	0.30
(2) DS, multiple step dimming .....	0.20
(3) DS, ON/OFF .....	0.10
(4) DS continuous dimming and programmable timing .....	0.35
(5) DS multiple step dimming and programmable timing .....	0.25
(6) DS ON/OFF and programmable timing .....	0.15
(7) DS continuous dimming, programmable timing, and lumen maintenance .....	0.40
(8) DS multiple step dimming, programmable timing, and lumen maintenance .....	0.30
(9) DS ON/OFF, programmable timing, and lumen maintenance .....	0.20
(10) Lumen maintenance control .....	0.10
(11) Lumen maintenance and programmable timing control .....	0.15
(12) Programmable timing control .....	0.15



TABLE 401.3.3.—LIGHTING POWER ADJUSTMENT FACTORS—Continued

Automatic control devices	PAF
(13) Occupancy sensor (OS) .....	0.30
(14) OS and DS, continuous dimming .....	0.40
(15) OS and DS, multiple-step dimming .....	0.35
(16) OS and DS, ON/OFF .....	0.35
(17) OS, DS continuous dimming, and lumen maintenance .....	0.45
(18) OS, DS multiple-step dimming and lumen maintenance .....	0.40
(19) OS, DS ON/OFF, and lumen maintenance .....	0.35
(20) OS and lumen maintenance .....	0.35
(21) OS and programmable timing control .....	0.35

#### 401.3.4 Lighting Controls

401.3.4.1 Type of Lighting Controls. All lighting systems shall have controls, with the exception of emergency use or exit lighting.

401.3.4.2 Number of Manual Controls. Spaces enclosed by walls or ceiling-high partitions shall have a minimum of one manual control (on/off switch) for lighting in that space. Additional manual controls shall be provided for each task location or for each group of task locations within an area of 450 ft<sup>2</sup> or less. For spaces with only one lighting fixture or with a single ballast, one manual control is required. Exceptions are as follows:

401.3.4.2.1 Continuous lighting for security;

401.3.4.2.2 Systems in which occupancy sensors, local programmable timers, or three-level (including OFF) step controls or preset dimming controls are substituted for manual controls at the rate of one for every two required manual controls, providing at least one control is installed for every 1500 watts of power.

401.3.4.2.3 Systems in which four-level (including OFF) step controls or preset dimming controls or automatic or continuous dimming controls are substituted for manual controls at a rate of one for every three required manual controls, providing at least one control is installed for every 1500 watts of power.

401.3.4.2.4 Spaces that must be used as a whole, such as public lobbies, retail stores, warehouses, and storerooms.

401.3.4.3 Multiple Location Controls. Manual controls that operate the same load from multiple locations must be counted as one manual control.

401.3.4.4 Control Accessibility. Lighting controls shall be readily accessible from within the space controlled. Exceptions are as follows: Controls for spaces that are used as a whole, automatic controls, programmable controls, controls requiring trained operators, and controls for safety hazards and security.

401.3.4.5 Hotel and Motel Guest Room Control. Hotel and motel guest rooms and suites shall have at least one master switch at the main entry door that controls all permanently wired lighting fixtures and switched receptacles excluding bathrooms. The following exception applies: Where switches are provided at the entry to each room of a multiple-room suite.

401.3.4.6 Switching of Exterior Lighting. Exterior lighting not intended for 24-hour use shall be automatically switched by either timer or photocell or a combination of timer and photocell. When used, timers shall be capable of seven-day and seasonal daylight schedule adjustment and have power backup for at least four hours.

#### 401.3.5 Ballasts.

401.3.5.1 Tandem Wiring. One-lamp or three-lamp fluorescent luminaries that are recess mounted within 10 ft center-to-center of each other, or pendant mounted, or surface mounted within 1 ft of each other, and within the same room, shall be tandem wired, unless three-lamp ballasts are used.

401.3.5.2 Power Factor. All ballasts shall have a power factor of at least 90%, with the exception of dimming ballasts, and ballasts for circline and compact fluorescent lamps and low wattage HID lamps not over 100 W.

#### § 434.402 Building envelope assemblies and materials.

The building envelope and its associated assemblies and materials shall meet the provisions of this section.

402.1 Calculations and Supporting Information.

402.1.1 Material Properties. Information on thermal properties, building envelope system performance, and component heat transfer shall be obtained from RS-4. When the information is not available from RS-4, the data shall be obtained from manufacturer's information or laboratory or field test measurements using RS-5, RS-6, RS-7, or RS-8.

402.1.1.1 The shading coefficient (SC) for fenestration shall be obtained

from RS-4 or from manufacturer's test data. The shading coefficient of the fenestration, including both internal and external shading devices, is SC<sub>x</sub> and excludes the effect of external shading projections, which are calculated separately. The shading coefficient used for louvered shade screens shall be determined using a profile angle of 30 degrees as found in Table 41, Chapter 27 of RS-4.

402.1.2 Thermal Performance Calculations. The overall thermal transmittance of the building envelope shall be calculated in accordance with Equation 402.1.2:

$$U_o = \Sigma U_i A_i / A_o = (U_1 A_1 + U_2 A_2 + \dots + U_N A_N) / A_o \quad (402.1.2)$$

where:

$U_o$  = the area-weighted average thermal transmittance of the gross area of the building envelope; i.e., the exterior wall assembly including fenestration and doors, the roof and ceiling assembly, and the floor assembly, Btu/(h•ft<sup>2</sup>•°F)

$A_o$  = the gross area of the building envelope, ft<sup>2</sup>

$U_i$  = the thermal transmittance of each individual path of the building envelope, i.e., the opaque portion or the fenestration, Btu/(h•ft<sup>2</sup>•°F)

$U_i = 1/R_i$  (where  $R_i$  is the total resistance to heat flow of an individual path through the building envelope)

$A_i$  = the area of each individual element of the building envelope, ft<sup>2</sup>

The thermal transmittance of each component of the building envelope shall be determined with due consideration of all major series and parallel heat flow paths through the elements of the component and film coefficients and shall account for any compression of insulation. The thermal transmittance of opaque elements of assemblies shall be determined using a series path procedure with corrections for the presence of parallel paths within an element of the envelope assembly (such as wall cavities with parallel paths through insulation and studs). The thermal performance of adjacent

ground in below-grade applications shall be excluded from all thermal calculations.

402.1.2.1 Envelope Assemblies Containing Metal Framing. The thermal transmittance of the envelope assembly containing metal framing shall be determined from one of three methods:

(a) Laboratory or field test measurements based on RS-5, RS-6, RS-7, or RS-8.

(b) The zone method described in Chapter 22 of RS-4 and the formulas on page 22.10.

(c) For metal roof trusses or metal studs covered by Tables 402.1.2.1a and b, the total resistance of the series path shall be calculated in accordance with the following Equations:

Equation 402.1.2.1a

$$U_i = 1/R_t$$

$$R_t = R_i + R_e$$

where:

$R_t$  = the total resistance of the envelope assembly

$R_i$  = the resistance of the series elements (for  $i = 1$  to  $n$ ) excluding the parallel path element(s)

$R_e$  = the equivalent resistance of the element containing the parallel path ( $R$ -value of insulation  $\times F_c$ ). Values for  $F_c$  and equivalent resistances shall be taken from Tables 402.1.2.1a or b.

TABLE 402.1.2.1a.—PARALLEL PATH CORRECTION FACTORS—METAL ROOF TRUSSES SPACED 4 FT. O.C. OR GREATER THAT PENETRATE THE INSULATION

Effective framing/cavity R-values	Correction factor $F_c$	Equivalent resistance $R_e$ <sup>1</sup>
R-0 .....	1.00	R-0
R-5 .....	0.96	R-4.8
R-10 .....	0.92	R-9.2
R-15 .....	0.88	R-13.2
R-20 .....	0.85	R-17.0
R-25 .....	0.81	R-20.3
R-30 .....	0.79	R-23.7
R-35 .....	0.76	R-26.6
R-40 .....	0.73	R-29.2
R-45 .....	0.71	R-32.0
R-50 .....	0.69	R-34.5
R-55 .....	0.67	R-36.0

<sup>1</sup> Based on 0.66-inch-diameter cross members every one foot.

TABLE 402.1.2.1b.—PARALLEL PATH CORRECTION FACTORS—METAL FRAMED WALLS WITH STUDS 16 GA. OR LIGHTER

Size of members	Spacing of framing, in.	Cavity insulation R-value	Correction factor $F_c$	Equivalent resistance $R_e$
2×4 .....	16 O.C.	R-11	0.50	R-5.0
		R-13	0.46	R-6.0
		R-15	0.43	R-6.4
2×4 .....	24 O.C.	R-11	0.60	R-6.6
		R-13	0.55	R-7.2
		R-15	0.52	R-7.8
2×6 .....	16 O.C.	R-19	0.37	R-7.1
		R-21	0.43	R-9.0
2×6 .....	24 O.C.	R-19	0.45	R-8.6
		R-21	0.35	R-7.4
2×8 .....	16 O.C.	R-25	0.31	R-7.8
2×8 .....	24 O.C.	R-25	0.38	R-9.6

402.1.2.2 Envelope Assemblies Containing Nonmetal Framing. The thermal transmittance of the envelope assembly shall be determined from laboratory or field test measurements based on RS-5, RS-6, RS-7, or RS-8 or from the series-parallel (isothermal

planes) method provided in page 23.2 of Chapter 23 of RS-4.

402.1.2.3 Metal Buildings. For elements with internal metallic structures bonded on one or both sides to a metal skin or covering, the calculation procedure specified in RS-9 shall be used.

402.1.2.4 Fenestration Assemblies. Calculation of the overall thermal transmittance of fenestration assemblies shall consider the center-of-glass, edge-of-glass, and frame components.

(a) The following equation 402.1.2.4a shall be used.

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**Equation 402.1.2.4a****Equation 402.1.2.4a**

$$\begin{aligned}
 U_{of} &= [\sum_{i=1}^n (U_{cg,i} \times A_{cg,i} + U_{eg,i} \times A_{eg,i} + U_{fi} \times A_{fi})] / \\
 &\quad [\sum_{i=1}^n (A_{cg,i} + A_{eg,i} + A_{fi})] \\
 &= (U_{cg,1} \times A_{cg,1} + U_{eg,1} \times A_{eg,1} + U_{f,1} \times A_{f,1} + U_{cg,2} \\
 &\quad \times A_{cg,2} + U_{eg,2} \times A_{eg,2} + U_{f,2} \times A_{f,2} \\
 &\quad + \dots U_{cg,n} \times A_{cg,n} + U_{eg,n} \times A_{eg,n} + U_{f,n} \times A_{f,n}) / (A_{cg,1} \\
 &\quad + A_{eg,1} + A_{f,1} + A_{cg,2} + A_{eg,2} \\
 &\quad + A_{f,2} + \dots A_{cg,n} + A_{eg,n} + A_{f,n}) \\
 U_{of} &= [\sum_{i=1}^n (U_{cg,i} \times A_{cg,i} + U_{eg,i} \times A_{eg,i} + U_{fi} \times A_{fi})] / \\
 &\quad [\sum_{i=1}^n (A_{cg,i} + A_{eg,i} + A_{fi})] \\
 &= (U_{cg,1} \times A_{cg,1} + U_{eg,1} \times A_{eg,1} + U_{f,1} \times A_{f,1} + U_{cg,2} \\
 &\quad \times A_{cg,2} + U_{eg,2} \times A_{eg,2} + U_{f,2} \times A_{f,2} \\
 &\quad + \dots U_{cg,n} \times A_{cg,n} + U_{eg,n} \times A_{eg,n} + U_{f,n} \times A_{f,n}) / (A_{cg,1} \\
 &\quad + A_{eg,1} + A_{f,1} + A_{cg,2} + A_{eg,2} \\
 &\quad + A_{f,2} + \dots A_{cg,n} + A_{eg,n} + A_{f,n})
 \end{aligned}$$

where:

- $U_{of}$  = the overall thermal transmittance of the fenestration assemblies, including the center-of-glass, edge-of-glass, and frame components, Btu/(h·ft<sup>2</sup>·°F)
- $i$  = numerical subscript (1, 2, . . . n) refers to each of the various fenestration types present in the wall
- $n$  = the number of fenestration assemblies in the wall assembly
- $U_{cg}$  = the thermal transmittance of the center-of-glass area, Btu/(h·ft<sup>2</sup>·°F)
- $A_{cg}$  = the center of glass area, that is the overall visible glass area minus the edge-of-glass area, ft<sup>2</sup>
- $U_{eg}$  = the thermal transmittance of the edge of the visible glass area including the effects of spacers in multiple glazed units, Btu/(h·ft<sup>2</sup>·°F)
- $A_{eg}$  = the edge of the visible glass area, that is the 2.5 in. perimeter band adjacent to the frame, ft<sup>2</sup>
- $U_f$  = the thermal transmittance of the frame area, Btu/(h·ft<sup>2</sup>·°F)
- $A_f$  = the frame area that is the overall area of the entire glazing product minus the center-of-glass area and minus the edge-of-glass area, ft<sup>2</sup>

(1) Results from laboratory test of center-of-glass, edge-of-glass, and frame assemblies tested as a unit at winter conditions. One of the procedures in Section 8.3.2 of RS-1 shall be used.

(2) Overall generic product C (commercial) in Table 13, Chapter 27, of the RS-4. The generic product C in Table 13, Chapter 27, is based on a product of 24 ft<sup>2</sup>. Larger units will produce lower U-values and thus it is recommended to use the calculation procedure detailed in Equation 402.1.2.4a.

(3) Calculations based on the actual area for center-of-glass, edge-of-glass, and frame assemblies and on the thermal transmittance of components derived from 402.1.2.4a, 402.1.2.4b or a combination of the two.

#### 402.1.3 Gross Areas of Envelope Components.

402.1.3.1 Roof Assembly. The gross area of a roof assembly shall consist of the total surface of the roof assembly exposed to outside air or unconditioned spaces and is measured from the exterior faces of exterior walls and

centerline of walls separating buildings. The roof assembly includes all roof or ceiling components through which heat may flow between indoor and outdoor environments, including skylight surfaces but excluding service openings. For thermal transmittance purposes when return air ceiling plenums are employed, the roof or ceiling assembly shall not include the resistance of the ceiling or the plenum space as part of the total resistance of the assembly.

402.1.3.2 Floor Assembly. The gross area of a floor assembly over outside or unconditioned spaces shall consist of the total surface of the floor assembly exposed to outside air or unconditioned space and is measured from the exterior face of exterior walls and centerline of walls separating buildings. The floor assembly shall include all floor components through which heat may flow between indoor and outdoor or unconditioned space environments.

402.1.3.3 Wall Assembly. The gross area of exterior walls enclosing a heated or cooled space is measured on the exterior and consists of the opaque

walls, including between-floor spandrels, peripheral edges of flooring, window areas (including sash), and door areas but excluding vents, grilles, and pipes.

402.2 Air Leakage and Moisture Mitigation. The requirements of this section shall apply only to those building components that separate interior building conditioned space from the outdoors or from unconditioned space or crawl spaces. Compliance with the criteria for air leakage through building components shall be determined by tests conducted in accordance with RS-10.

402.2.1 Air Barrier System. A barrier against leakage shall be installed to prevent the leakage of air through the building envelope according to the following requirements:

(a) The air barrier shall be continuous at all plumbing and heating penetrations of the building opaque wall.

(b) The air barrier shall be sealed at all penetrations of the opaque building wall for electrical and telecommunications equipment.

TABLE 402.2.1.—AIR LEAKAGE FOR FENESTRATION AND DOORS—MAXIMUM ALLOWABLE INFILTRATION RATE

Component	Reference standard	cfm/lin ft sash crack or cfm/ft <sup>2</sup> of area
<b>Fenestration</b>		
Aluminum:		
Operable .....	RS-11 .....	0.37 cfm/lin ft
Jalousie .....	RS-11 .....	1.50 cfm/ft <sup>2</sup>
Fixed .....	RS-11 .....	0.15 cfm/ft <sup>2</sup>
PVC: Prime Windows .....	RS-12 .....	0.06 cfm/ft <sup>2</sup>
Wood:		
Residential .....	RS-13 .....	0.37 cfm/ft <sup>2</sup>
Light Commercial .....	RS-13 .....	0.25 cfm/ft <sup>2</sup>
Heavy Commercial .....	RS-13 .....	0.15 cfm/ft <sup>2</sup>
<b>Sliding Glass Doors</b>		
Aluminum .....	RS-11 .....	0.37 cfm/ft <sup>2</sup>
PVC .....	RS-12 .....	0.37 cfm/lin ft
Doors—Wood:		
Residential .....	RS-14 .....	0.34 cfm/ft <sup>2</sup>
Light Commercial .....	RS-14 .....	0.25 cfm/ft <sup>2</sup>
Heavy Commercial .....	RS-14 .....	0.10 cfm/ft <sup>2</sup>
Commercial Entrance Doors .....	RS-10 .....	1.25 cfm/ft <sup>2</sup>
Residential Swinging Doors .....	RS-10 .....	0.50 cfm/ft <sup>2</sup>
Wall Sections Aluminum .....	RS-10 .....	0.06 cfm/ft <sup>2</sup>

**Note:** [The "Maximum Allowable Infiltration Rates" are from current standards to allow the use of available products.]

402.2.2 Building Envelope. The following areas of the building envelope shall be sealed, caulked, gasketed, or weatherstripped to limit air leakage:

(a) Intersections of the fenestration and door frames with the opaque wall sections.

(b) Openings between walls and foundations, between walls and roof and wall panels.

(c) Openings at penetrations of utility service through, roofs, walls, and floors.

(d) Site built fenestration and doors.

(e) All other openings in the building envelope.

Exceptions are as follows: Outside air intakes, exhaust outlets, relief outlets, stair shaft, elevator shaft smoke relief openings, and other similar elements shall comply with subsection 403.

402.2.2.1 Fenestration and Doors. Fenestration and doors shall meet the requirements of Table 402.2.1.

402.2.2.2 Building Assemblies Used as Ducts or Plenums. Building assemblies used as ducts or plenums shall be sealed, caulked, and gasketed to limit air leakage.

402.2.2.3 Vestibules. A door that separates conditioned space from the exterior shall be equipped with an

enclosed vestibule with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule, it is not necessary for the interior and exterior doors to open at the same time. Exceptions are as follows: Exterior doors need not be protected with a vestibule where:

(a) The door is a revolving door.  
(b) The door is used primarily to facilitate vehicular movement or material handling.

(c) The door is not intended to be used as a general entrance door.

(d) The door opens directly from a dwelling unit.

(e) The door opens directly from a retail space less than 2,000 ft<sup>2</sup> in area, or from a space less than 1,500 ft<sup>2</sup> for other uses.

(f) In buildings less than three stories in building height in regions that have less than 6,300 heating degree days base 65°F.

**402.2.2.4 Compliance Testing.** All buildings shall be tested after completion using the methodology in RS-11, or an equivalent approved method to determine the envelope air leakage. A standard blower door test is an acceptable technique to pressurize the building if the building is 5,000 ft<sup>2</sup> or less in area. The building's air handling system can be used to pressurize the building if the building is larger than 5,000 ft<sup>2</sup>. The following test conditions shall be:

(a) The measured envelope air leakage shall not exceed 1.57 pounds per square foot of wall area at a pressure difference of 0.3 inches water.

(b) At the time of testing, all windows and outside doors shall be installed and closed, all interior doors shall be open, and all air handlers and dampers shall be operable. The building shall be unoccupied.

(c) During the testing period, the average wind speed during the test shall be less than 6.6 feet per second, the average outside temperature greater than 59°F, and the average inside-outside temperature difference is less than 41°F.

**402.2.2.5 Moisture Migration.** The building envelope shall be designed to limit moisture migration that leads to deterioration in insulation or equipment performance as determined by the following construction practices:

(a) A vapor retarder shall be installed to retard, or slow down the rate of water vapor diffusion through the building envelope. The position of the vapor retarder shall be determined taking into account local climate and indoor humidity levels. The methodologies presented in Chapter 20 of RS-4 shall be

used to determine temperature and water vapor profiles through the envelope systems to assess the potential for condensation within the envelope and to determine the position of the vapor retarder within the envelope system.

(b) The vapor retarder shall be installed over the entire building envelope.

(c) The perm rating requirements of the vapor retarder shall be determined using the methodologies contained in Chapter 20 of RS-4, and shall take into account local climate and indoor humidity level. The vapor retarder shall have a performance rating of 1 perm or less.

#### 402.3 Thermal Performance Criteria.

**402.3.1 Roofs; Floors and Walls** Adjacent to Unconditioned Spaces. The area weighted average thermal transmittance of roofs and also of floors and walls adjacent to unconditioned spaces shall not exceed the criteria in Table 402.3.1a. Exceptions are as follows: Skylights for which daylight credit is taken may be excluded from the calculations of the roof assembly  $U_{or}$  if all of the following conditions are met:

(a) The opaque roof thermal transmittance is less than the criteria in Table 402.3.1b.

(b) Skylight areas, including framing, as a percentage of the roof area do not exceed the values specified in Table 402.3.1b. The maximum skylight area from Table 402.3.1b may be increased by 50% if a shading device is used that blocks over 50% of the solar gain during the peak cooling design condition. For shell buildings, the permitted skylight area shall be based on a light level of 30-foot candles and a lighting power density (LPD) of less than 1.0 w/ft<sup>2</sup>. For speculative buildings, the permitted skylight area shall be based on the unit lighting power allowance from Table 401.3.2a and an illuminance level as follows: for LPD < 1.0, use 30 footcandles; for 1.0 < LPD < 2.5, use 50 footcandles; and for LPD ≥ 2.5, use 70 footcandles.

(c) All electric lighting fixtures within daylighted zones under skylights are controlled by automatic daylighting controls.

(d) The  $U_o$  of the skylight assembly including framing does not exceed \_\_\_\_\_ Btu/(h•ft<sup>2</sup>•°F). [Use 0.70 for ≥ 8000 HDD65 and 0.45 for >8000 HDD65 or both if the jurisdiction includes cities that are both below and above 8000 HDD65.]

(e) Skylight curb U-value does not exceed 0.21 Btu/(h•ft<sup>2</sup>•°F).

(f) The infiltration coefficient of the skylights does not exceed 0.05 cfm/ft<sup>2</sup>.

**402.3.2 Below-Grade Walls and Slabs-on-Grade.** The thermal resistance (R-value) of insulation for slabs-on-grade, or the overall thermal resistances of walls in contact with the earth, shall be equal to or greater than the values in Table 403.3.2.

**402.4 Exterior Walls.** Exterior walls shall comply with either 402.4.1 or 402.4.2.

**402.4.1 Prescriptive Criteria.** (a) The exterior wall shall be designed in accordance with subsections 402.4.1.1 and 402.4.1.2. When the internal load density range is not known, the 0–1.50 W/ft<sup>2</sup> range shall be used for residential, hotel/motel guest rooms, or warehouse occupancies; the 3.01–3.50 W/ft<sup>2</sup> range shall be used for retail stores smaller than 2,000 ft<sup>2</sup> and technical and vocational schools smaller than 10,000 ft<sup>2</sup>; and the 1.51–3.00 W/ft<sup>2</sup> range shall be used for all other occupancies and building sizes. When the building envelope is designed or constructed prior to knowing the building occupancy type, an internal load density of \_\_\_\_\_ W/ft<sup>2</sup> shall be used. [Use 3.0 W/ft<sup>2</sup> for HDD65 < 3000, 2.25 W/ft<sup>2</sup> for 3000 < HDD65 < 6000, and 1.5 W/ft<sup>2</sup> for HDD65 > 6000.]

(b) When more than one condition exists, area weighted averages shall be used. This requirement shall apply to all thermal transmittances, shading coefficients, projection factors, and internal load densities rounded to the same number of decimal places as shown in the respective table.

**402.4.1.1 Opaque Walls.** The weighted average thermal transmittance (U-value) of opaque wall elements shall be less than the values in Table 402.4.1.1. For mass walls (HC≥5), criteria are presented for low and high window/wall ratios and the criteria shall be determined by interpolating between these values for the window/wall ratio of the building.

**402.4.1.2 Fenestration.** The design of the fenestration shall meet the criteria of Table 402.4.1.2. When the fenestration columns labeled "Perimeter Daylighting" are used, automatic daylighting controls shall be installed in the perimeter daylighted zones of the building. These daylighting controls shall be capable of reducing electric lighting power to at least 50% of full power. Only those shading or lighting controls for perimeter daylighting that are shown on the plans shall be considered. The column labeled "VLT > = SC" shall be used only when the shading coefficient of the glass is less than its visible light transmittance.

**Example Alternate Component Package Table**

The example Alternate Component Package tables illustrate the requirements of subsections 301.1,

402.3.1, 402.3.2, 402.4.1.1 and 402.4.1.2. Copies of specific tables contained in this example can be obtained from the Energy Code for Federal Commercial Buildings, Docket No. EE-RM-79-112-C, Buildings Division, EE-432, Office of

Codes and Standards, U.S. Department of Energy, Room 1J-018, 1000 Independence Avenue, SW., Washington, DC 20585, (202) 586-0517.

**BILLING CODE 6450-01-P**

10CFR 434 - Federal Commercial Building Energy Code - May 1995  
Albany, NY #4

TABLE 402.4.1.2 MAXIMUM WINDOW WALL RATIO (WWR)											
Internal Load Density (ILD) Range	Projection Factor (PF) Range	Shading Coefficient (SCx) Range	Penetration U-Factor (U <sub>f</sub> )		Perimeter Daylighting		VLT ≥ SC				
			Base Case								
			0.59 to 0.53	0.52 to 0.40	0.39 to 0.00	0.59 to 0.53	0.52 to 0.40	0.39 to 0.00			
0.00 - 1.50	0.00 - 0.25	1.00 - 0.72	23	25	27	24	26	29			
		0.71 - 0.61	26	28	32	27	29	33			
		0.60 - 0.51	29	31	36	29	32	37			
		0.50 - 0.39	31	34	40	31	35	42			
		0.38 - 0.26	34	38	47	34	38	48			
			0.25 - 0.00	38	43	56	38	43	56		
	0.26 - 0.50	1.00 - 0.72	30	32	37	31	33	39			
		0.71 - 0.61	33	36	43	33	36	44			
		0.60 - 0.51	35	38	47	35	39	49			
		0.50 - 0.39	37	41	51	36	41	53			
0.38 - 0.00		39	44	57	38	44	58				
1.51 - 3.00	0.50 +	1.00 - 0.72	35	38	46	35	38	48			
		0.71 - 0.61	37	41	51	37	41	53			
		0.60 - 0.51	39	43	55	38	43	56			
		0.50 - 0.00	40	45	59	39	44	59			
		1.00 - 0.72	20	21	23	25	26	29			
	0.00 - 0.25	0.71 - 0.61	23	25	27	28	30	34			
		0.60 - 0.51	26	28	31	30	33	38			
		0.50 - 0.39	29	31	35	33	36	43			
		0.38 - 0.26	33	36	42	36	40	50			
		0.25 - 0.00	39	43	53	40	45	59			
3.01 - 3.50	0.26 - 0.50	1.00 - 0.72	27	28	31	31	33	40			
		0.71 - 0.61	30	32	37	34	37	45			
		0.60 - 0.51	33	35	41	36	40	50			
		0.50 - 0.39	35	39	46	38	42	54			
		0.38 - 0.00	39	43	53	41	46	60			
	0.50 +	1.00 - 0.72	32	34	39	35	39	49			
		0.71 - 0.61	35	38	45	38	42	54			
		0.60 - 0.51	37	41	50	39	44	58			
		0.50 - 0.00	39	44	54	41	46	62			
		1.00 - 0.72	18	19	20	24	25	28			
3.01 - 3.50	0.00 - 0.25	0.71 - 0.61	21	22	24	27	29	33			
		0.60 - 0.51	24	25	28	30	32	38			
		0.50 - 0.39	27	28	32	32	35	42			
		0.38 - 0.26	31	33	39	36	39	50			
		0.25 - 0.00	37	40	50	40	45	59			
	0.26 - 0.50	1.00 - 0.72	24	25	28	30	33	39			
		0.71 - 0.61	27	29	33	33	36	45			
		0.60 - 0.51	30	32	37	35	39	49			
		0.50 - 0.39	33	36	42	37	41	54			
		0.38 - 0.00	37	40	49	40	45	60			
0.50 +	1.00 - 0.72	29	31	35	34	38	48				
	0.71 - 0.61	32	35	41	37	41	53				
	0.60 - 0.51	35	38	45	38	43	57				
	0.50 - 0.00	37	41	50	40	45	61				
	1.00 - 0.72	29	31	35	34	38	48				

10CFR 434 - Federal Commercial Building Energy Code - May 1995  
Albany, NY #4

TABLE 301.1 EXTERIOR DESIGN CONDITIONS									
WINTER Design Dry Bulb: minus 6°F;					HDD65: 6770				
SUMMER Design Dry Bulb: 88°F; Mean Coincident Wet Bulb: 72°F;					CDD65: 619				
Annual Operating Hours, 8AM - 4PM when 55°F<=T<=69°F: 605									
TABLE 402.3.1(A) MAX. THERMAL TRANSMITTANCE(U)									
Roof	Wall adjacent to unconditioned space				0.053				
Floor over unconditioned space					0.128				
					0.046				
TABLE 402.3.1(B) MAX. EXEMPT SKYLIGHT AREA AS % OF ROOF AREA									
Visible Light Transmittance (VLT)	Light level Ft. Candles	Range of Lighting Power Densities							
		<1.00	1.00 - 1.50	1.51 - 2.00	>2.00				
0.75	30	2.3	3.4	4.5	5.6				
	50	2.5	4.0	5.5	7.0				
	70	2.8	4.6	6.4	8.2				
0.50	30	3.6	5.1	6.6	8.1				
	50	3.9	6.0	8.1	10.2				
	70	4.2	6.9	9.6	12.3				
TABLE 402.3.2 MINIMUM THERMAL RESISTANCE (R-VALUE)									
Slab on grade: Unheated / Heated:		24 inches		36 inches		48 inches			
Horizontal Vertical		R-17/R-19		R-14/R-16		R-11/R-13			
		R-8/R-10		R-6/R-8		R-4/R-6			
Wall below grade:				R-10					
TABLE 402.4.1.1 MAX. WALL THERMAL TRANSMITTANCE (U <sub>w</sub> )									
ILD Range	WWR	HC Range	Insulation Position						
			Interior/Integral	Exterior					
0.00 to 1.50	23	0.0 - 4.9	0.080	0.080					
		5.0 - 9.9	0.084	0.103					
		10.0 - 14.9	0.090	0.114					
1.51 to 3.00	59	15.0 +	0.095	0.118					
		5.0 - 9.9	0.083	0.097					
		10.0 - 14.9	0.087	0.105					
3.01 to 3.50	20	15.0 +	0.091	0.108					
		5.0 - 9.9	0.085	0.109					
		10.0 - 14.9	0.093	0.125					
3.51 to 4.00	62	15.0 +	0.100	0.130					
		5.0 - 9.9	0.083	0.099					
		10.0 - 14.9	0.088	0.109					
4.01 to 4.50	18	15.0 +	0.092	0.112					
		5.0 - 9.9	0.085	0.111					
		10.0 - 14.9	0.094	0.128					
4.51 to 5.00	61	15.0 +	0.102	0.134					
		5.0 - 9.9	0.083	0.100					
		10.0 - 14.9	0.088	0.110					
5.01 to 5.50		15.0 +	0.093	0.114					
		5.0 - 9.9	0.088	0.110					
		10.0 - 14.9	0.093	0.114					

402.4.2 System Performance Criteria. The cumulative annual energy flux attributable to thermal transmittance and solar gains shall be less than the criteria determined using the ENVSTD21 computer program in Standard 90.1-1989, or the equations in RS-1, Attachment 8-B. The cumulative annual energy flux shall be calculated using the ENVSTD21 computer program or the equations in RS-1, Attachment 8-B.

TABLE 402.4.2.—EQUIP DEFAULT VALUES FOR ENVSTD21

Occupancy	Default equipment power density <sup>1</sup>	Default occupant load adjustment <sup>1</sup>	Default adjusted equipment power density
Assembly .....	0.25	0.75	1.00
Health/Institutional .....	1.00	-0.26	0.74
Hotel/Motel .....	0.25	-0.33	0.00
Warehouse/Storage .....	0.10	-0.60	0.00
Multi-Family High Rise .....	0.75	N/A	0.00
Office .....	0.75	-0.35	0.40
Restaurant .....	0.10	0.07	0.17

TABLE 402.4.2.—EQUIP DEFAULT VALUES FOR ENVSTD21—Continued

Occupancy	Default equipment power density <sup>1</sup>	Default occupant load adjustment <sup>1</sup>	Default adjusted equipment power density
Retail .....	0.25	-0.38	0.00
School .....	0.50	0.30	0.80

<sup>1</sup> Defaults as defined in Section 8.6.10.5, Table 8-4, and Sections 8.6.10.6 and 13.7.2.1, Table 13-2 from RS-1.

402.4.2.1 Equipment Power Density (EQUIP). The equipment power density used in the ENVSTD21 computer program shall use the actual equipment power density from the building plans and specifications or be taken from Table 402.4.2 using the column titled "Default Adjusted Equipment Power Density" or calculated for the building using the procedures of RS-1. The program limits consideration of the equipment power density to a maximum of 1 W/ft<sup>2</sup>.

402.4.2.2 Lighting Power Density (LIGHTS). The lighting power density used in the ENVSTD21 computer program shall use the actual lighting

power density from the building plans and specifications or the appropriate value from Tables 401.3.2a, b, c, or d.

402.4.2.3 Daylighting Control Credit Fraction (DLCF). When the daylighting control credit fraction is other than zero, automatic daylighting controls shall be installed in the appropriate perimeter zone(s) of the building to justify the credit.

#### § 434.403 Building Mechanical Systems and Equipment.

Mechanical systems and equipment used to provide heating, ventilating, and air conditioning functions as well as additional functions not related to space conditioning, such as, but not limited to, freeze protection in fire projection systems and water heating, shall meet the requirements of this section.

403.1 Mechanical Equipment Efficiency. When equipment shown in Tables 403.1a through 403.1f is used, it shall have a minimum performance at the specified rating conditions when tested in accordance with the specified reference standard. Omission of minimum performance requirements for equipment not listed in Tables 403.1a through 403.1f does not preclude use of such equipment.

TABLE 403.1a—UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum Efficiency <sup>b</sup>	Test Procedure <sup>a</sup>
Air Conditioners, Air Cooled .....	<65,000 Btu/h .....	Split System .....	10.0 SEER	ARI 210/240 (RS-15).
		Single Package .....	9.7 SEER.	ARI 210/240 (RS-15).
		Split System and Single Package.	8.9 EER <sup>c</sup> 8.3 IPLV <sup>c</sup>	
		Split System and Single Package.	8.5 EER <sup>c</sup> 7.5 IPLV <sup>c</sup>	
		Split System and Single Package.	8.5 EER <sup>c</sup> 7.5 IPLV <sup>c</sup>	ARI-360 (RS-16).
Air Conditioners, Water and Evaporatively Cooled.	<65,000 Btu/h .....	Split System and Single Package.	8.2 EER <sup>c</sup> 7.5 IPLV <sup>c</sup>	ARI-360 (RS-16).
		Split System and Single Package.	9.3 EER <sup>c</sup> 8.4 IPLV <sup>c</sup>	ARI 210/240 (RS-15).
		Split System and Single Package.	10.5 EER <sup>c</sup> 9.7 IPLV <sup>c</sup>	ARI 210/240 (RS-15).
		Split System and Single Package.	9.6 EER <sup>c</sup> 9.0 IPLV <sup>c</sup>	ARI-360 (RS-16).
		Split System and Single Package.	9.6 EER <sup>c</sup> 9.0 IPLV <sup>c</sup>	ARI-360 (RS-16).
Condensing Units, Air Cooled .....	≥135,000 Btu/h .....	.....	9.9 EER 11.0 IPLV	ARI 365 (RS-29).
Condensing Units, Water or Evaporatively Cooled.	≥135,000 Btu/h .....	.....	12.9 EER 12.9 IPLV	ARI 365 (RS-29).

<sup>a</sup> See § 434.500 for detailed references.

<sup>b</sup> Deduct 0.2 from the required EER's and IPLV's for units that have a heating section.

<sup>c</sup> IPLV's are only applicable to equipment with capacity modulation.



TABLE 403.1b.—UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency <sup>b</sup>	Test procedure <sup>a</sup>
Air Cooled (Cooling Mode) .....	< 65,000 Btu/h .....	Split System .....	10.0 SEER	ARI 210/240 (RS-15).
		Single Package .....	9.7 SEER	
		Split System and Single Package.	8.9 EER <sup>c</sup> 8.3 IPLV <sup>c</sup>	ARI 210/240 (RS-15).
		Split System and Single Package.	8.5 EER <sup>c</sup> 7.5 IPLV <sup>c</sup>	ARI-340 (RS-17).
Water Source (Cooling Mode) .....	< 65,000 Btu/h .....	Split System and Single Package.	8.5 EER <sup>c</sup> 7.5 IPLV <sup>c</sup>	ARI-340 (RS-17).
		85 °F Entering Water .....	9.3 EER	ARI-320 (RS-27).
		75 °F Entering Water .....	10.2 EER	
		85 °F Entering Water .....	10.5 EER	ARI-320 (RS-27).
Groundwater-Source (Cooling Mode) ...	< 135,000 Btu/h .....	75 °F Entering Water .....	11.0 EER	
		70 °F Entering Water .....	11.0 EER	ARI 325 (RS-28).
Ground Source (Cooling Mode) .....	< 135,000 Btu/h .....	50 °F Entering Water .....	11.5 EER	
		77 °F Entering Water .....	10.0 EER	ARI 325 (RS-28).
Air Cooled (Heating Mode) .....	< 65,000 Btu/h (Cooling Capacity).	70 °F Entering Water .....	10.4 EER	
		Split System .....	6.8 HSPF	ARI 210/240 (RS-15).
		Single Package .....	6.6 HSPF	
		47 °F db/43 °F wb Outdoor Air.	3.00 COP	ARI 210/240 (RS-15).
Water-Source (Heating Mode) .....	< 135,000 Btu/h (Cooling Capacity).	17 °F db/15 °F wb Outdoor Air.	2.00 COP	
		47 °F db/43 °F wb Outdoor Air.	2.90 COP	ARI-340 (RS-17).
		17 °F db/15 °F wb Outdoor Air.	2.00 COP	
		70 °F Entering Water .....	3.80 COP	ARI-320 (RS-27).
Groundwater-Source (Heating Mode) ...	< 135,000 Btu/h (Cooling Capacity).	75 °F Entering Water .....	3.90 COP	
		70 °F Entering Water .....	3.40 COP	ARI 325 (RS-28).
Ground Source (Heating Mode) .....	< 135,000 Btu/h (Cooling Capacity).	50 °F Entering Water .....	3.00 COP	
		32 °F Entering Water .....	2.50 EER	ARI-330 (RS-45).
		41 °F Entering Water .....	2.70 EER	

<sup>a</sup> See § 434.500 for detailed references<sup>b</sup> Deduct 0.2 from the required EER's and IPLV's for units that have a heating section.<sup>c</sup> IPLV's are only applicable to equipment with capacity modulation.

TABLE 403.1c.—WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency <sup>b</sup>	Test procedure <sup>a</sup>
Air-Cooled, With Condenser, Electrically Operated.	< 150 Tons .....	.....	2.70 COP 2.80 IPLV	ARI 550 Centrifugal/Rotary Screw (RS-30) or ARI 590 Reciprocating (RS-31).
		.....	2.50 COP 2.50 IPLV	
Air-Cooled, Without Condenser, Electrically Operated.	All Capacities .....	.....	3.10 COP 3.20 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating).	All Capacities .....	.....	3.80 COP 3.90 IPLV	
		.....	3.80 COP 3.90 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll).	< 150 Tons .....	.....	3.80 COP 3.90 IPLV	
		.....	4.20 COP 4.50 IPLV	
		.....	5.20 COP 5.30 IPLV	

TABLE 403.1c.—WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS—Continued

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency <sup>b</sup>	Test procedure <sup>a</sup>
Water-Cooled, Electrically Operated Centrifugal.	<150 Tons .....	.....	380 COP	ARI 550 (RS-30).
	≥ 150 Tons and < 300 Tons .....	.....	3.90 IPLV	
	≥ 300 Tons .....	.....	4.20 COP	
Absorption Single Effect .....	All Capacities .....	.....	4.50 IPLV	ARI 560 (RS-46).
		.....	5.20 COP	
		.....	5.30 IPLV	
Absorption Double Effect, Indirect-Fired	All Capacities .....	.....	0.48 COP	
		.....	0.95 COP	
		.....	1.00 IPLV	
Absorption Double-Effect, Direct-Fired	All Capacities .....	.....	0.95 COP	
		.....	1.00 IPLV	
		.....	1.00 IPLV	

<sup>a</sup> See § 434.500 for detailed references.<sup>b</sup> Equipment must comply with all efficiencies when multiple efficiencies are indicated.

TABLE 403.1d.—PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, ROOM AIR CONDITIONERS, AND ROOM AIR-CONDITIONER HEAT PUMPS ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency	Test procedure <sup>a</sup>
PTAC (Cooling Mode) .....	All Capacities .....	95°F db Outdoor Air .....	10.0 – (0.16× Cap/1,000) <sup>b</sup> EER	ARI 310 (RS-18).
		82°F db Outdoor Air .....	12.2 – (0.20× Cap/1,000) <sup>b</sup> EER	
PTHP (Cooling Mode) .....	All Capacities .....	95°F db Outdoor Air .....	10.0 – (0.16× Cap/1,000) <sup>b</sup> EER	ARI 380 (RS-19).
		82°F db Outdoor Air .....	12.2 – (0.20× Cap/1,000) <sup>b</sup> EER	
PTHP (Heating Mode) .....	All Capacities .....	.....	2.90 – (0.26× CAP/1,000) <sup>b</sup> COP	
		.....	8.0 EER	
Room Air Conditioners, With Louvered Sides.	<6,000 Btu/h .....	.....	8.5 EER	ANSI/AHAM RAC-1 (RS-40).
	≥6,000 Btu/h and <8,000 Btu/h .....	.....	9.0 EER	
	≥8,000 Btu/h and <14,000 Btu/h .....	.....	8.8 EER	
	≥14,000 Btu/h and <20,000 Btu/h .....	.....	8.2 EER	
	≥20,000 Btu/h .....	.....	8.0 EER	
Room Air Conditioners, Without Louvered Sides.	<6,000 Btu/h .....	.....	8.5 EER	ANSI/AHAM RAC-1 (RS-40).
	≥6,000 Btu/h and <20,000 Btu/h .....	.....	8.2 EER	
	≥20,000 Btu/h .....	.....	8.5 EER	
Room Air-Conditioner Heat Pumps With Louvered Sides.	All Capacities .....	.....	8.0 EER	ANSI/AHAM RAC-1 (RS-40).
Room Air-Conditioner Heat Pumps Without Louvered Sides.	All Capacities .....	.....	8.0 EER	ANSI/AHAM RAC-1 (RS-40).

<sup>a</sup> See § 434.500 for detailed references.<sup>b</sup> Equipment must comply with all efficiencies when multiple efficiencies are indicated. (Note products covered by the 1992 Energy Policy Act have no efficiency requirement for operation at other than standard rating conditions for products manufactured after 1/1/94).<sup>c</sup> Cap means the rated capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

TABLE 403.1e.—WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency <sup>d</sup>	Test procedure <sup>a</sup>
Warm Air-Furnace, Gas-Fired .....	<225,000 Btu/h .....	.....	78% AGUE or 80% E <sub>t</sub> <sup>c</sup>	DOE 10 CFR 430 (RS-20).
	≥225,000 Btu/h .....	Maximum Capacity <sup>c</sup> Minimum Capacity <sup>c</sup> .....	80% E <sub>t</sub> <sup>c</sup>	
Warm Air-Furnace, Oil-Fired .....	<225,000 Btu/h .....	.....	78% E <sub>t</sub> <sup>c</sup>	ANSI Z21.47 (RS-21).
			78% AGUE or 80% E <sub>t</sub> <sup>c</sup>	

TABLE 403.1e.—WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS—Continued

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency <sup>d</sup>	Test procedure <sup>a</sup>
Warm Air Duct Furnaces, Gas-Fired ....	≥225,000 Btu/h .....	Maximum Capacity <sup>b</sup> Minimum Capacity <sup>b</sup> .....	81% E <sub>t</sub> 81% E <sub>t</sub>	U.L. 727 (RS–22).
	All Capacities .....	Maximum Capacity <sup>b</sup> Minimum Capacity <sup>b</sup> .....	78% E <sub>t</sub> 74% E <sub>t</sub>	ANSI Z83.9 (RS–23).
Warm Air Unit Heaters, Gas Fired .....	All Capacities .....	Maximum Capacity <sup>b</sup> Minimum Capacity <sup>b</sup> .....	78% E <sub>t</sub> 74% E <sub>t</sub>	ANSI Z83.8 (RS–24).
	All Capacities .....	Maximum Capacity <sup>b</sup> Minimum Capacity <sup>b</sup> .....	81% E <sub>t</sub> 81% E <sub>t</sub>	U.L. 731 (RS–25).

<sup>a</sup> See § 434.500 for detailed references.

<sup>b</sup> Minimum and maximum ratings as provided for and allowed by the unit's controls.

<sup>c</sup> Combination units not covered by NAECA (Three-phase power or cooling capacity ≥65,000 Btu/h) may comply with either rating.

<sup>d</sup> E<sub>t</sub>=thermal efficiency. See referenced document for detailed discussion.

<sup>e</sup> E<sub>c</sub>=combustion efficiency. Units must also include an IID and either power venting or a flue damper. For those furnaces where combustion air is drawn from the conditioned space, a vent damper may be substituted for a flue damper.

TABLE 403.1f.—BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency <sup>c</sup>	Test procedure <sup>a</sup>
Boilers, Gas-Fired .....	<300,000 Btu/h .....	Hot Water .....	80% AGUE	DOE 10 CFR 430 (RS–20).
		Steam .....	75% AGUE	DOE 10 CFR 430 (RS–20).
Boilers, Oil-Fired .....	≥300,000 Btu/h .....	Maximum Capacity <sup>b</sup> .....	80% E <sub>c</sub>	ANSI Z21.13 (RS–32).
		Minimum Capacity <sup>b</sup> .....	80% E <sub>c</sub>	
	<300,000 Btu/h .....	Maximum Capacity <sup>b</sup> .....	83% E <sub>c</sub>	DOE 10 CFR 430 (RS–20).
		Minimum Capacity <sup>b</sup> .....	83% E <sub>c</sub>	U.L. 726 (RS–33).
Oil-Fired (Residual) .....	≥300,000 Btu/h .....	Maximum Capacity <sup>b</sup> .....	83% E <sub>c</sub>	
		Minimum Capacity <sup>b</sup> .....	83% E <sub>c</sub>	

<sup>a</sup> See § 434.500 for detailed references.

<sup>b</sup> Minimum and maximum ratings as provided for and allowed by the unit's controls.

<sup>c</sup> E<sub>c</sub>=combustion efficiency (100% less flue losses). See reference document for detailed information.

403.1.1 Where multiple rating conditions and/or performance requirements are provided, the equipment shall satisfy all stated requirements.

403.1.2 Equipment used to provide water heating functions as part of a combination integrated system shall satisfy all stated requirements for the appropriate space heating or cooling category.

403.1.3 The equipment efficiency shall be supported by data furnished by the manufacturer or shall be certified under a nationally recognized certification program or rating procedure.

403.1.4 Where components, such as indoor or outdoor coils, from different manufacturers are used, the system designer shall specify component efficiencies whose combined efficiency meets the standards herein.

#### 403.2 HVAC Systems.

403.2.1 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–1 using the design parameters specified in subpart C of this part.

403.2.2 Equipment and System Sizing. Heating and cooling equipment and systems shall be sized to provide no more than the loads calculated in accordance with subsection 403.2.1. A single piece of equipment providing both heating and cooling must satisfy this provision for one function with the other function sized as small as possible to meet the load, within available equipment options. Exceptions are as follows:

(a) When the equipment selected is the smallest size needed to meet the load within available options of the desired equipment line.

(b) Standby equipment provided with controls and devices that allow such equipment to operate automatically only when the primary equipment is not operating.

(c) Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that sequence or otherwise optimally control the operation of each unit based on load.

403.2.3 Separate Air Distribution System. Zones with special process temperature and/or humidity requirements shall be served by air distribution systems separate from those serving zones requiring only comfort conditions or shall include supplementary provisions so that the primary systems may be specifically controlled for comfort purposes only. Exceptions: Zones requiring only comfort heating or comfort cooling that are served by a system primarily used for process temperature and humidity control need not be served by a separate system if the total supply air to these comfort zones is no more than 25% of the total system supply air or the total conditioned floor area of the zones is less than 1000 ft<sup>2</sup>.

403.2.4 Ventilation and Fan System Design. Ventilation systems shall be designed to be capable of reducing the supply of outdoor air to the minimum ventilation rates required by Section 6.1.3 of RS-41 through the use of return ducts, manually or automatically operated control dampers, fan volume controls, or other devices. Exceptions are as follows: Minimum outdoor air rates may be greater if:

(a) Required to make up air exhausted for source control of contaminants such as in a fume hood.

(b) Required by process systems.

(c) Required to maintain a slightly positive building pressure. For this purpose, minimum outside air intake may be increased up to no greater than 0.30 air changes per hour in excess of exhaust quantities.

403.2.4.1 Ventilation controls for variable or high occupancy areas. Systems with design outside air capacities greater than 3,000 cfm serving areas having an average design occupancy density exceeding 100 people per 1,000 ft<sup>2</sup> shall include means to automatically reduce outside air intake to the minimum values required by RS-41 during unoccupied or low-occupancy periods. Outside air shall not be reduced below 0.14 cfm/ft<sup>2</sup>. Outside air intake shall be controlled by one or more of the following:

(a) A clearly labeled, readily accessible bypass timer that may be used by occupants or operating personnel to temporarily increase minimum outside air flow up to design levels.

(b) A carbon dioxide (CO<sub>2</sub>) control system having sensors located in the spaces served, or in the return air from the spaces served, capable of maintaining space CO<sub>2</sub> concentrations below levels recommended by the manufacturer, but no fewer than one sensor per 25,000 ft<sup>2</sup> of occupied space shall be provided.

(c) An automatic timeclock that can be programmed to maintain minimum outside air intake levels commensurate with scheduled occupancy levels.

(d) Spaces equipped with occupancy sensors.

403.2.4.2 Ventilation Controls for enclosed parking garages: Garage ventilation fan systems with a total design capacity greater than 30,000 cfm shall have automatic controls that stage fans or modulate fan volume as required to maintain carbon monoxide (CO) below levels recommended in RS-41.

403.2.4.3 Ventilation and Fan Power. The fan system energy demand of each HVAC system at design conditions shall not exceed 0.8 W/cfm of supply air for constant air volume

systems and 1.25 W/cfm of supply air for variable-air-volume (VAV) systems. Fan system energy demand shall not include the additional power required by air treatment or filtering systems with pressure drops over 1 in. w.c. Individual VAV fans with motors 75 hp and larger shall include controls and devices necessary for the fan motor to demand no more than 50 percent of design wattage at 50 percent of design air volume, based on manufacturer's test data. Exceptions are as follows:

(a) Systems with total fan system motor horsepower of 10 hp or less.

(b) Unitary equipment for which the energy used by the fan is considered in the efficiency ratings of subsection 403.1.

403.2.5 Pumping System Design. HVAC pumping systems used for comfort heating and/or comfort air conditioning that serve control valves designed to modulate or step open and closed as a function of load shall be designed for variable fluid flow and capable of reducing system flow to 50 percent of design flow or less.

Exceptions are as follows:

(a) Systems where a minimum flow greater than 50% of the design flow is required for the proper operation of equipment served by the system, such as chillers.

(b) Systems that serve no more than one control valve.

(c) Systems with a total pump system horse power ≤10 hp.

(d) Systems that comply with subsection 403.2.6.8 without exception.

403.2.6 Temperature and Humidity Controls.

403.2.6.1 System Controls. Each heating and cooling system shall include at least one temperature control device.

403.2.6.2 Zone Controls. The supply of heating and cooling energy to each zone shall be controlled by individual thermostatic controls responding to temperature within the zone. For the purposes of this section, a dwelling unit is considered a zone. Exception: Independent perimeter systems that are designed to offset building envelope heat losses or gains or both may serve one or more zones also served by an interior system when the perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one orientation for at least 50 contiguous ft and the perimeter system heating and cooling supply is controlled by thermostat(s) located within the zone(s) served by the system.

403.2.6.3 Zone Thermostatic Control Capabilities. Where used to control comfort heating, zone thermostatic

controls shall be capable of being set locally or remotely by adjustment or selection of sensors down to 55 °F or lower. Where used to control comfort cooling, zone thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors up to 85 °F or higher. Where used to control both comfort heating and cooling, zone thermostatic controls shall be capable of providing a temperature range or deadband of at least 5 °F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Exceptions are as follows:

(a) Special occupancy or special usage conditions approved by the building official or

(b) Thermostats that require manual changeover between heating and cooling modes.

403.2.6.4 Heat Pump Auxiliary Heat. Heat pumps having supplementary electric resistance heaters shall have controls that prevent heater operation when the heating load can be met by the heat pump. Supplemental heater operation is permitted during outdoor coil defrost cycles not exceeding 15 minutes.

403.2.6.5 Humidistats. 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% or increase relative humidity above 30%.

403.2.6.6 Simultaneous Heating and Cooling. Zone thermostatic and humidistatic controls shall be capable of operating in sequence the supply of heating and cooling energy to the zone. Such controls shall prevent: reheating; recooling; mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by mechanical refrigeration or by economizer systems; and other simultaneous operation of heating and cooling systems to the same zone.

Exceptions are as follows:

(a) Variable-air-volume systems that, during periods of occupancy, are designed to reduce the air supply to each zone to a minimum before heating, recooling, or mixing takes place. This minimum volume shall be no greater than the larger of 30% of the peak supply volume, the minimum required to meet minimum ventilation requirements of the Federal agency, (0.4 cfm/ft<sup>2</sup> of zone conditioned floor area, and 300 cfm).

(b) Zones where special pressurization relationships or cross-contamination requirements are such that variable-air-volume systems are impractical, such as isolation rooms,

operating areas of hospitals and clean rooms.

(c) At least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.

(d) Zones where specified humidity levels are required to satisfy process needs, such as computer rooms and museums.

(e) Zones with a peak supply air quantity of 300 cfm or less.

**403.2.6.7 Temperature Reset for Air Systems.** Air systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply air temperatures by representative building loads or by outside air temperature. Temperature shall be reset by at least 25% of the design supply air to room air temperature difference. Zones that are expected to experience relatively constant loads, such as interior zones, shall be designed for the fully reset supply temperature. Exception are as follows: Systems that comply with subsection 403.2.6.6 without using exceptions (a) or (b).

**403.2.6.8 Temperature Reset for Hydronic Systems.** Hydronic systems of at least 600,000 Btu/hr design capacity supplying heated and/or chilled water to comfort conditioning systems shall include controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature. Temperature shall be reset by at least 25% of the design supply-to-return water temperature difference. Exceptions are as follows:

(a) Systems that comply with subsection 403.2.5 without exception or  
(b) where the design engineer certifies to the building official that supply temperature reset controls cannot be implemented without causing improper operation of heating, cooling, humidification, or dehumidification systems.

**403.2.7 Off Hour Controls.**

**403.2.7.1 Automatic Setback or Shutdown Controls.** HVAC systems shall be equipped with automatic controls capable of accomplishing a reduction of energy use through control setback or equipment shutdown. Exceptions are as follows:

(a) Systems serving areas expected to operate continuously or  
(b) equipment with full load demands not exceeding 2 kW controlled by readily accessible, manual off-hour controls.

**403.2.7.2 Shutoff Dampers.** Outdoor air supply and exhaust systems shall be provided with motorized or gravity dampers or other means of automatic

volume shutoff or reduction. Exceptions are as follows:

(a) Systems serving areas expected to operate continuously.

(b) Individual systems which have a design airflow rate or 3000 cfm or less.

(c) Gravity and other non-electrical ventilation systems controlled by readily accessible, manual damper controls.

(d) Where restricted by health and life safety codes.

**403.2.7.3 Zone Isolation systems** that serve zones that can be expected to operate nonsimultaneously for more than 750 hours per year shall include isolation devices and controls to shut off or set back the supply of heating and cooling to each zone independently. Isolation is not required for zones expected to operate continuously or expected to be inoperative only when all other zones are inoperative. For buildings where occupancy patterns are not known at the time of system design, such as speculative buildings, the designer may predesignate isolation areas. The grouping of zones on one floor into a single isolation area shall be permitted when the total conditioned floor area does not exceed 25,000 ft<sup>2</sup> per group.

**403.2.8 Economizer Controls.**

**403.2.8.1** Each fan system shall be designed and capable of being controlled to take advantage of favorable weather conditions to reduce mechanical cooling requirements. The system shall include either: a temperature or enthalpy air economizer system that is capable of automatically modulating outside air and return air dampers to provide up to 85% of the design supply air quantity as outside air, or a water economizer system that is capable of cooling supply air by direct and/or indirect evaporation and is capable of providing 100% of the expected system cooling load at outside air temperatures of 50°F dry-bulb/45°F wet-bulb and below. Exceptions are as follows:

(a) Individual fan-cooling units with a supply capacity of less than 3000 cfm or a total cooling capacity less than 90,000 Btu/h.

(b) Systems with air-cooled or evaporatively cooled condensers that include extensive filtering equipment provided in order to meet the requirements of RS-41.

(c) Systems with air-cooled or evaporatively cooled condensers where the design engineer certifies to the building official that use of outdoor air cooling affects the operation of other systems, such as humidification, dehumidification, and supermarket

refrigeration systems, so as to increase overall energy usage.

(d) Systems that serve envelope-dominated spaces whose sensible cooling load at design conditions, excluding transmission and infiltration loads, is less than or equal to transmission and infiltration losses at an outdoor temperature of 60°F.

(e) Systems serving residential spaces and hotel or motel rooms.

(f) Systems for which at least 75% of the annual energy used for mechanical cooling is provided from a site-recovered or site-solar energy source.

(g) The zone(s) served by the system each have operable openings (windows, doors, etc.) with an openable area greater than 5% of the conditioned floor area. This applies only to spaces open to and within 20 ft of the operable openings. Automatic controls shall be provided that lock out system mechanical cooling to these zones when outdoor air temperatures are less than 60°F.

**403.2.8.2 Economizer systems** shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load. Exceptions are as follows:

(a) Direct-expansion systems may include controls to reduce the quantity of outdoor air as required to prevent coil frosting at the lowest step of compressor unloading. Individual direct-expansion units that have a cooling capacity of 180,000 Btu/h or less may use economizer controls that preclude economizer operation whenever mechanical cooling is required simultaneously.

(b) Systems in climates with less than 750 average operating hours per year between 8 a.m. and 4 p.m. when the ambient dry-bulb temperatures are between 55 °F and 69 °F inclusive.

**403.2.8.3 System design and economizer controls** shall be such that economizer operation does not increase the building heating energy use during normal operation.

**403.2.9 Distribution System Construction and Insulation.**

**403.2.9.1 Piping Insulation.** All HVAC system piping shall be thermally insulated in accordance with Table 403.2.9.1. Exceptions are as follows:

(a) Factory-installed piping within HVAC equipment tested and rated in accordance with subsection 403.1.

(b) Piping that conveys fluids that have a design operating temperature range between 55°F and 105°F.

(c) Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electricity.

TABLE 403.2.9.1.—MINIMUM PIPE INSULATION (IN.) 5a

Fluid Design Operating Temp. Range (°F)	Insulation conductivity <sup>a</sup>		Nominal Pipe Diameter (in.)			
	Conductivity Range Btu.in./ (h-ft <sup>2</sup> ·°F)	Mean Rating Temp. °F	<1.0	1.0 to 1.25	1.5 to 3.0	4.0 to 6.0
Heating Systems (Steam, Steam Condensate, and Hot Water) <sup>b, c</sup>						
>350 .....	0.32–0.34 .....	250	1.0	1.5	1.5	2.5
251–350 .....	0.29–0.32 .....	200	1.0	1.0	1.5	2.0
201–250 .....	0.27–0.30 .....	150	1.0	1.0	1.0	1.5
141–200 .....	0.25–0.29 .....	125	1.0	1.0	1.0	1.5
105–140 .....	0.22–0.28 .....	100	0.5	0.5	0.75	1.0
Domestic and Service Hot Water Systems						
105 and Greater .....	0.22–0.28 .....	100	0.5	0.5	0.75	1.0
Cooling Systems (Chilled Water, Brine, and Refrigerant) <sup>d</sup>						
40–55 .....	0.22–0.28 .....	100	0.5	0.5	0.5	0.5
Below 40 .....	0.22–0.28 .....	100	0.5	0.5	0.5	0.5

<sup>a</sup> For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$$T = r \{ (1 + t/r)^{K/k} - 1 \}$$

Where T=minimum insulation thickness (in), r=actual outside radius of pipe (in), t=insulation thickness listed in this table for applicable fluid temperature and pipe size, K=conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu.in./h-ft<sup>2</sup>·°F); and k=the upper value of the conductivity range listed in this table for the applicable fluid temperature.

<sup>b</sup> These thicknesses are based on energy efficiency considerations only. Safety issues, such as insulation surface temperatures, have not been considered.

<sup>c</sup> Piping insulation is not required between the control valve and coil on run-outs when the control valve is located within four feet of the coil and the pipe diameter is 1 inch or less.

<sup>d</sup> Note that the required minimum thickness does not take water vapor transmission and possible surface condensation into account.

TABLE 403.2.9.2.—Minimum Duct Insulation R-value <sup>a</sup>

Duct location	Cooling supply ducts				Heating supply ducts				Return ducts
	CDD65 ≤500	500< CDD65 ≤1,000	1,000< CDD65 ≤2,000	CDD65 ≥2,000	HDD65 ≤1,500	1,500< HDD65 ≤4,500	4,500< HDD65 ≤7,500	HDD65 ≥7,500	
Exterior of Building .....	R–3.3 .....	R–5.0 .....	R–6.5 .....	R–8.0 .....	R–3.3 .....	R–5.0 .....	R–6.5 .....	R–8.0 .....	R–5.0
Ventilated Attic .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–3.3
Unvented Attic .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–3.3
Other Conditioned Spaces <sup>b</sup> .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3
Indirectly Conditioned Spaces <sup>c</sup> .....	none .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	R–3.3 .....	none
Buried .....	none .....	none .....	none .....	none .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–5.0 .....	R–3.3

<sup>a</sup> Insulation R-values, measured in (h·ft<sup>2</sup>·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thickness do not consider water vapor transmission and possible surface condensation. The required minimum thicknesses do not consider water vapor transmission and condensation. For ducts that are designed to convey both heated and cooled air, duct insulation shall be as required by the most restrictive condition. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of this section or subsection 402. Insulation resistance measured on a horizontal plane in accordance with RS–6 at a mean temperature of 75 °F.

<sup>b</sup> Includes crawl spaces, both ventilated and non-ventilated.

<sup>c</sup> Includes return air plenums, with and without exposed roofs above.

**403.2.9.2 Duct and Plenum Insulation.** All supply and return air ducts and plenums installed as part of an HVAC air distribution system shall be thermally insulated in accordance with Table 403.2.9.1. Exceptions are as follows:

(a) Factory-installed plenums, casings, or ductwork furnished as a part of the HVAC equipment tested and rated in accordance with subsection 403.1

(b) Ducts within the conditioned space that they serve.

**403.2.9.3 Duct and Plenum Construction.** All air-handling ductwork and plenums shall be constructed and erected in accordance with RS–34, RS–35, and RS–36. Where supply ductwork and plenums designed to operate at static pressures from 0.25 in. wc to 2 in. wc, inclusive, are located outside of the conditioned space or in return plenums, joints shall be sealed in accordance with Seal Class C as defined in RS–34. Pressure sensitive tape shall not be used as the primary sealant where such ducts

are designed to operate at static pressures of 1 in. wc, or greater.

**403.2.9.3.1 Ductwork designed to operate at static pressures in excess of 3 in. wc shall be leak-tested in accordance with Section 5 of RS–35, or equivalent. Test reports shall be provided in accordance with Section 6 of RS–35, or equivalent. The tested duct leakage class at a test pressure equal to the design duct pressure class rating shall be equal to or less than leakage Class 6 as defined in Section 4.1 of RS–**

35. Representative sections totaling at least 25% of the total installed duct area for the designated pressure class shall be tested.

#### 403.2.10 Completion.

403.2.10.1 Manuals. Construction documents shall require an operating and maintenance manual provided to the Federal Agency. The manual shall include, at a minimum, the following:

(a) Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance, including assumptions used in outdoor design calculations.

(b) Operating and maintenance manuals for each piece of equipment requiring maintenance. Required maintenance activity shall be specified.

(c) Names and addresses of at least one qualified service agency to perform the required periodic maintenance shall be provided.

(d) HVAC controls systems maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field determined setpoints shall be permanently recorded on control drawings, at control devices, or, for digital control systems, in programming comments.

(e) A complete narrative, prepared by the designer, of how each system is intended to operate shall be included with the construction documents.

403.2.10.2 Drawings. Construction documents shall require that within 30 days after the date of system acceptance, record drawings of the actual installation be provided to the Federal agency. The drawings shall include details of the air barrier installation in every envelope component, demonstrating continuity of the air barrier at all joints and penetrations.

403.2.10.3 Air System Balancing. Construction documents shall require that all HVAC systems be balanced in accordance with the industry accepted procedures (such as National Environmental Balancing Bureau (NEBB) Procedural Standards, Associated Air Balance Council (AABC) National Standards, or ANSI/ASHRAE Standard 111). Air and water flow rates shall be measured and adjusted to deliver final flow rates within 10% of design rates, except variable flow distribution systems need not be balanced upstream of the controlling device (VAV box or control valve).

403.2.10.3.1 Construction documents shall require a written balance report be provided to the Federal agency for HVAC systems serving zones with a total conditioned area exceeding 5,000 ft<sup>2</sup>.

403.2.10.3.2 Air systems shall be balanced in a manner to first minimize throttling losses, then fan speed shall be adjusted to meet design flow conditions or equivalent procedures. Exception: Damper throttling may be used for air system balancing;

(a) With fan motors of 1 hp (0.746 kW) or less, or

(b) Of throttling results in no greater than 1/3 hp (0.248 kW) fan horsepower draw above that required if the fan speed were adjusted.

403.2.10.4 Hydronic System Balancing. Hydronic systems shall be balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Exceptions are as follows:

(a) Pumps with pump motors of 10 hp (7.46 kW) or less.

(b) If throttling results in no greater than 3 hp (2.23 kW) pump horsepower draw above that required if the impeller were trimmed.

(c) To reserve additional pump pressure capability in open circuit piping systems subject to fouling. Valve throttling pressure drop shall not exceed that expected for future fouling.

403.2.10.5 Control System Testing. HVAC control systems shall be tested to assure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft<sup>2</sup> conditioned area, detailed instructions for commissioning HVAC systems shall be provided by the designer in plans and specifications.

#### § 434.404 Building service systems and equipment.

404.1 Service Water Heating Equipment Efficiency. Equipment must satisfy the minimum performance efficiency specified in Table 404.1 when tested in accordance with RS-37, RS-38, or RS-39. Omission of equipment from Table 404.1 shall not preclude the use of such equipment. Service water heating equipment used to provide additional function of space heating as part of a combination (integrated) system shall satisfy all stated requirements for the service water heating equipment. All gas-fired storage water heaters that are not equipped with a flue damper and use indoor air for combustion or draft hood dilution and that are installed in a conditioned space, shall be equipped with a vent damper listed in accordance with RS-42. Unless the water heater has an available electrical supply, the installation of such a vent damper shall not require an electrical connection.

TABLE 404.1.—MINIMUM PERFORMANCE OF WATER HEATING EQUIPMENT

Category	Type	Fuel	Input Rating	V <sub>T</sub>	Input to V <sub>T</sub> ratio Btuh/gal	Test method <sup>a</sup>	Energy factor	Thermal efficiency E <sub>t</sub> %	Standby loss %/HR
NAECA covered water heating equipment <sup>b</sup>	All	Electric	≤12 kW	All <sup>c</sup>		DOE Test Procedure 10 CFR, Part 430 (RS-37)	≥0.93–0.00132V		
	Storage	Gas	≤75,000 Btuh	All <sup>c</sup>			≥0.62–0.0019V		
	Instantaneous	Gas	≤200,000 Btuh <sup>c</sup>	All			≥0.62–0.0019V		
	Storage	Oil	≤105,000 Btuh	All			≥0.59–0.0019V		
	Instantaneous	Oil	≤210,000 Btuh	All			≥0.59–0.0019V		
Other water heating Equipment <sup>d</sup>	Pool heater	Gas/oil	All	All		ANSI Z21.56 (RS-38)		≥78	
	Storage	Electric	All	All		ANSI Z21.10.3 (RS-39)		≥78	≤0.30+27/V <sub>T</sub>
	Storage/instantaneous	Gas/oil	≤155,000 Btuh	All	<4,000			≥78	≤1.3+114/V <sub>T</sub>
			>155,000 Btuh	All	<4,000			≥80	≤1.3+95V <sub>T</sub>
				<10	≥4,000			≥77	≤2.3+67/V <sub>T</sub>
Unfired storage tanks				≥10	≥4,000				≤6.5 Btuh/ft <sup>2</sup>

<sup>a</sup> For detailed references see § 434.500.

<sup>b</sup> Consistent with National Appliance Energy Conservation Act (NAECA) of 1987.

<sup>c</sup> DOE Test Procedures apply to electric and gas storage water heaters with rated volumes ≥20 gallons and gas instantaneous water heaters with input ratings of 50,000 to 200,000 Btuh.

<sup>d</sup> All except those water heaters covered by NAECA.

#### 404.1.1 Testing Electric and Oil Storage Water Heaters for Standby Loss.

(a) When testing an electric storage water heater, the procedures of Z21.10.3-1990 (RS-39), Section 2.9, shall be used. The electrical supply voltage shall be maintained with  $\pm 1\%$  of the center of the voltage range specified on the water heater nameplate. Also, when needed for calculations, the thermal efficiency ( $E_t$ ) shall be 98%. When testing an oil-fired water heater, the procedures of Z21.10.3-1990 (RS-39), Sections 2.8 and 2.9, shall be used.

(b) The following modifications shall be made: A vertical length of flue pipe shall be connected to the flue gas outlet of sufficient height to establish the minimum draft specified in the manufacturer's installation instructions. All measurements of oil consumption shall be taken by instruments with an accuracy of  $\pm 1\%$  or better. The burner rate shall be adjusted to achieve an hourly Btu input rate within  $\pm 2\%$  of the manufacturer's specified input rate with the  $\text{CO}_2$  reading as specified by the manufacturer with smoke no greater than 1 and the fuel pump pressure within  $\pm 1\%$  of the manufacturer's specification.

404.1.2 Unfired Storage Tanks. The heat loss of the tank surface area Btu/( $\text{h}\cdot\text{ft}^2$ ) shall be based on an  $80^\circ\text{F}$  water-air temperature difference.

404.1.3 Storage Volume Symbols in Table 404.1. The symbol "V" is the rated storage volume in gallons as specified by the manufacturer. The symbol " $V_T$ " is the storage volume in gallons as measured during the test to determine the standby loss.  $V_T$  may differ from V, but it is within tolerances allowed by the applicable Z21 and Underwriters Laboratories standards. Accordingly, for the purpose of estimating the standby loss requirement using the rated volume shown on the rating plate,  $V_T$  should be considered as no less than  $0.95V$  for gas and oil water heaters and no less than  $0.90V$  for electric water heaters.

404.2 Service Hot Water Piping Insulation. Circulating system piping and noncirculating systems without heat traps, the first eight feet of outlet piping from a constant-temperature noncirculating storage system, and the inlet pipe between the storage tank and a heat trap in a noncirculating storage system shall meet the provisions of subsection 403.2.9.

404.2.1 Vertical risers serving storage water heaters not having an integral heat trap and serving a noncirculating system shall have heat traps on both the inlet and outlet piping as close as practical to the water heater.

404.3 Service Water Heating System Controls. Temperature controls that allow for storage temperature adjustment from  $110^\circ\text{F}$  to a temperature compatible with the intended use shall be provided in systems serving residential dwelling units and from  $90^\circ\text{F}$  for other systems. When designed to maintain usage temperatures in hot water pipes, such as circulating hot water systems or heat trace, the system shall be equipped with automatic time switches or other controls that can be set to turn off the system.

404.3.1 The outlet temperature of lavatories in public facility restrooms shall be limited to  $110^\circ\text{F}$ .

404.4 Water Conservation. Shower heads and lavatories labeled as meeting the requirements of the Energy Policy Act (Pub. L. 102-486) shall be used.

404.4.1 Lavatories in public facility restrooms shall be equipped with a foot switch, occupancy sensor, or similar device or, in other than lavatories for physically handicapped persons, limit hot water delivery to  $0.25\text{ gal/cycle}$  for circulating systems and  $0.50\text{ gal/cycle}$  for noncirculating systems.

404.5 Swimming Pools. All pool heaters shall be equipped with a readily accessible on-off switch.

404.5.1 Time switches shall be installed on electric heaters and pumps. Exceptions are as follows:

(a) Pumps required to operate solar or heat recovery pool heating systems.

(b) Where public health requirements require 24-hour pump operation.

404.5.2 Heated swimming pools shall be equipped with pool covers. Exception: When over 70% of the annual energy for heating is obtained from a site-recovered or site-solar energy source.

404.6 Combined Service Water Heating and Space Heating Equipment. A single piece of equipment shall not be used to provide both space heating and service water heating. Exceptions are as follows:

(a) The energy input or storage volume of the combined boiler or water heater is less than twice the energy input or storage volume of the smaller of the separate boilers or water heaters otherwise required or

(b) the input to the combined boiler is less than 150,000 Btuh.

### Subpart E—Building Energy Cost Compliance Alternative

#### § 434.501 General.

501.1 This subpart E permits the use of the Building Energy Cost Compliance Alternative as an alternative to many elements of Subpart D of this part. When this subpart is used, it must be

used with Subpart C and Subpart D of this part, 401.1, 401.2, 401.3.4 and in conjunction with the minimum requirements found in subsections 402.1, 402.2, and 402.3., 403.1, 403.2.1-7, 403.9 and 404.

501.2 Compliance. Compliance under this method requires detailed energy analyses of the entire Proposed Design, referred to as the Design Energy Consumption; an estimate of annual energy cost for the proposed design, referred to as the Design Energy Cost; and comparison against an Energy Cost Budget. Compliance is achieved when the estimated Design Energy Cost is less than or equal to the Energy Cost Budget. This subpart provides instructions for determining the Energy Cost Budget and for calculating the Design Energy Consumption and Design Energy Cost. The Energy Cost Budget shall be determined through the calculation of monthly energy consumption and energy cost of a Prototype or Reference Building design configured to meet the requirements of subsections 401 through 404.

501.3 Designers are encouraged to employ the Building Energy Cost Budget compliance method set forth in this section for evaluating proposed design alternatives to using the elements prescribed in subpart D of this part. The Building Energy Cost Budget establishes the relative effectiveness of each design alternative in energy cost savings, providing an energy cost basis upon which the building owner and designer may select one design over another. This Energy Cost Budget is the highest allowable calculated energy cost for a specific building design. Other alternative designs are likely to have lower annual energy costs and life cycle costs than those used to minimally meet the Energy Cost Budget.

501.4 The Energy Cost Budget is a numerical reference for annual energy cost. Its purpose is to assure neutrality with respect to choices such as HVAC system type, architectural design and fuel choice by providing a fixed, repeatable budget that is independent of any of these choices wherever possible (i.e., for the prototype buildings). The Energy Cost Budget for a given building size and type will vary only with climate, the number of stories, and the choice of simulation tool. The specifications of the prototypes are necessary to assure repeatability, but have no other significance. They are not necessarily recommended energy conserving practice, or even physically reasonable practice for some climates or buildings, but represent a reasonable worst case of energy cost resulting from



compliance with the provisions of subsections 401 through 404.

**§ 434.502 Determination of the annual energy cost budget.**

502.1 The annual Energy Cost Budgets shall be determined in accordance with the Prototype Building Procedure in § 434.503 and § 434.504 or the Reference Building Procedure in § 434.505. Both methods calculate an annual Energy Cost by summing the 12 monthly Energy Cost Budgets. Each monthly Energy Cost Budget is the product of the monthly Building Energy Consumption of each type of energy used multiplied by the monthly Energy Cost per unit of energy for each type of energy used.

502.2 The Energy Cost Budget shall be determined in accordance with Equation 502.2.a as follows:

$$ECB = ECB_{jan} + \dots + ECB_m + \dots + ECB_{dec}$$

(Equation 502.2.a)

Based on:

$$ECB_m = BECON_{m1} \times ECOS_{m1} + \dots + BECON_{mi} \times ECOS_{mi}$$

(Equation 502.2.b)

Where:

ECB=The annual Energy Cost Budget  
 $ECB_m$ =The monthly Energy Cost Budget  
 $BECON_{mi}$ =The monthly Budget Energy Consumption of the  $i^{th}$  type of energy

$ECOS_{mi}$ =The monthly Energy Cost, per unit of the  $i^{th}$  type of energy

502.3 The monthly Energy Cost Budget shall be determined using current rate schedules or contract prices available at the building site for all types of energy purchased. These costs shall include demand charges, rate blocks, time of use rates, interruptible service rates, delivery charges, taxes, and all other applicable rates for the type, location, operation, and size of the proposed design. The monthly Budget Energy Consumption shall be calculated

from the first day through the last day of each month, inclusive.

**§ 434.503 Prototype building procedure.**

503.1 The Prototype Building procedure shall be used for all building types listed below. For mixed-use buildings the Energy Cost Budget is derived by allocating the floor space of each building type within the floor space of the prototype building. For buildings not listed below, the Reference Building procedure of § 434.505 shall be used. Prototype buildings include:

- (a) Assembly;
- (b) Office (Business);
- (c) Retail (Mercantile);
- (d) Warehouse (Storage);
- (e) School (Educational);
- (f) Hotel/Motel;
- (g) Restaurant;
- (h) Health/Institutional; and
- (i) Multi-Family.

**§ 434.504 Use of the prototype building to determine the energy cost budget.**

504.1 Determine the building type of the Proposed Design using the categories in subsection 503.1. Using the appropriate Prototype Building characteristics from all of the tables contained in this subpart E, the building shall be simulated using the same gross floor area and number of floors for the Prototype Building as in the Proposed Design.

504.2 The form, orientation, occupancy and use profiles for the Prototype Building shall be fixed as described in subsection 511. Envelope, lighting, other internal loads and HVAC systems and equipment shall meet the requirements of subsections 301, 401, 402, 403, and 404 and are standardized inputs.

**§ 434.505 Reference building method.**

505.1 The Reference Building procedure shall be used only when the

Proposed Design cannot be represented by one or a combination of the Prototype Building listed in subsection 503.1 or the assumptions for the Prototype Building in Subsection 510, such as occupancy and use-profiles, do not reasonably represent the Proposed Design.

**§ 434.506 Use of the reference building to determine the energy cost budget.**

506.1 Each floor shall be oriented in the same manner for the Reference Building as in the Proposed Design. The form, gross and conditioned floor areas of each floor and the number of floors shall be the same as in the Proposed Design. All other characteristics, such as lighting, envelope and HVAC systems and equipment, shall meet the requirements of subsections 301, 401, 402, 403 and 404.

**§ 434.507 Calculation procedure and simulation tool.**

507.1 The Prototype or Reference Buildings shall be modeled using the criteria of subsections 510 and 521. The modeling shall use a climate data set appropriate for both the site and the complexity of the energy conserving features of the design. ASHRAE Weather Year for Energy Calculations (WYEC) data or bin weather data shall be used in the absence of other appropriate data.

**§ 434.508 Determination of the design energy consumption and design energy cost.**

508.1 The Design Energy Consumption shall be calculated by modeling the Proposed Design using the same methods, assumptions, climate data, and simulation tool as were used to establish the Energy Cost Budget, except as explicitly stated in subsections 509 through 534. The Design Energy Cost shall be calculated per Equation 508.1.

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**Equation 508.1****Equation 508.1**

$$\text{DECOS} = \text{DECOS}_{\text{jan}} + \dots + \text{DECOS}_{\text{m}} + \dots + \text{DECOS}_{\text{mdec}}$$

**Equation 508.1**

Based on:

$$\text{DECOS}_m = \text{DECON}_m \times \text{ECOS}_{1m} + \dots + \text{DECON}_{mi} \times \text{ECOS}_{mi}$$

**Equation 508.1.2**

Where:

DECOS=The annual Design Energy Cost

DECOS<sub>m</sub>=The monthly Design Energy Cost

ICON<sub>mi</sub>=The monthly Design Energy Consumption of the i<sub>th</sub> type of energy

ECOS<sub>mi</sub>=The monthly Energy Cost per unit of the i<sub>th</sub> type of energy

The DECON<sub>mi</sub> shall be calculated from the first day through the last day of the month, inclusive.

**§ 434.509 Compliance.**

509.1 If the Design Energy Cost is less than or equal to the Energy Cost Budget, and all of the minimum requirements of subsection 501.2 are met, the Proposed Design complies with the standards.

**§ 434.510 Standard calculation procedure.**

510.1 The Standard Calculation Procedure consists of methods and assumptions for calculating the Energy Cost Budget for the Prototype or Reference Building and the Design Energy Consumption and Design Energy Cost of the Proposed Design. In order to maintain consistency between the Energy Cost Budget and the Design Energy Cost, the input assumptions to be used are stated below. These inputs shall be used to determine the Energy Cost Budget and the Design Energy Consumption.

510.2 Prescribed assumptions shall be used without variation. Default assumptions shall be used unless the designer can demonstrate that a different assumption better

characterizes the building's energy use over its expected life. The default assumptions shall be used in modeling both the Prototype or Reference Building and the Proposed Design, unless the designer demonstrates clear cause to modify these assumptions. Special procedures for speculative buildings are discussed in subsection 503. Shell buildings may not use Subpart E.

**§ 434.511 Orientation and shape.**

511.1 The Prototype Building shall consist of the same number of stories, and gross and conditioned floor area as the Proposed Design, with equal area per story. The building shape shall be rectangular, with a 2.5:1 aspect ratio. The long dimensions of the building shall face East and West. The fenestration shall be uniformly distributed in proportion to exterior wall area. Floor-to-floor height for the Prototype Building shall be 13 ft. except for dwelling units in hotels/motels and multi-family high-rise residential

buildings where floor-to-floor height shall be 9.5 ft.

511.2 The Reference Building shall consist of the same number of stories, and gross floor area for each story as the Proposed Design. Each floor shall be oriented in the same manner as the Proposed Design. The geometric form shall be the same as the Proposed Design.

**§ 434.512 Internal loads.**

512.1 The systems and types of energy specified in this section are provided only for purposes of calculating the Energy Cost Budget. They are not requirements for either systems or the type of energy to be used in the Proposed Design or for calculation of Design Energy Cost.

512.2 Internal loads for multi-family high-rise residential buildings are prescribed in Tables 512.2.a and b, Multi-Family High Rise Residential Building Schedules. Internal loads for other building types shall be modeled as noted in this subsection.

TABLE 512.2.a.—MULTI-FAMILY HIGH RISE RESIDENTIAL BUILDINGS SCHEDULES—ONE-ZONE DWELLING UNIT

[Internal Loads Per Dwelling Unit Btu/h]

Hour	Occupants		Lights	Equipment	
	Sensible	Latent	Sensible	Sensible	Latent
1 .....	300	260	0	750	110
2 .....	300	260	0	750	110
3 .....	300	260	0	750	110
4 .....	300	260	0	750	110
5 .....	300	260	0	750	110
6 .....	300	260	0	750	110
7 .....	300	260	0	750	110
8 .....	210	260	980	1250	190
9 .....	100	80	840	2600	420
10 .....	100	80	0	1170	180
11 .....	100	80	0	1270	190
12 .....	100	80	0	2210	330
13 .....	100	80	0	2210	330
14 .....	100	80	0	1270	190
15 .....	100	80	0	1270	190
16 .....	100	80	0	1270	190
17 .....	100	80	0	1270	190
18 .....	300	260	0	3040	450
19 .....	300	260	0	3360	500
20 .....	300	260	960	1490	220
21 .....	300	260	960	1490	220
22 .....	300	260	960	1490	220
23 .....	300	260	960	1060	160
24 .....	300	260	960	1060	160

TABLE 512.2.b.—MULTI-FAMILY HIGH RISE RESIDENTIAL BUILDING SCHEDULES—TWO-ZONE DWELLING UNIT  
[Internal Loads Per Dwelling Unit Btu/h]

Hour	Bedrooms and bathrooms					Other rooms				
	Occupants		Lights	Equipment		Occupants		Lights	Equipment	
	Sensible	Latent	Sensible	Sensible	Latent	Sensible	Latent	Sensible	Sensible	Latent
1	300	260	0	100	20	0	0	0	650	90
2	300	260	0	100	20	0	0	0	650	90
3	300	260	0	100	20	0	0	0	650	90
4	300	260	0	100	20	0	0	0	650	90
5	300	260	0	100	20	0	0	0	650	90
6	300	260	0	100	20	0	0	0	650	90
7	200	180	680	200	40	100	80	300	1050	150
8	110	120	240	200	40	100	80	600	2400	380
9	0	0	0	100	20	100	80	0	1070	160
0	0	0	0	100	20	100	80	0	1170	170
0	0	0	0	100	20	100	80	0	1170	170
0	0	0	0	100	20	100	80	0	2110	310
0	0	0	0	100	20	100	80	0	2110	310
14	0	0	0	100	20	100	80	0	1170	170
15	0	0	0	100	20	100	80	0	1170	170
16	0	0	0	100	20	100	80	0	1170	170
17	0	0	0	100	20	100	80	0	1170	170
18	0	0	0	100	20	300	260	0	2940	430
19	0	0	0	100	20	300	260	0	3260	480
20	100	80	320	300	60	200	180	640	1190	160
21	100	80	320	300	60	200	180	640	1190	160
22	150	130	480	700	90	150	130	480	790	130
23	300	260	640	410	70	0	0	320	650	90
24	300	260	640	410	70	0	0	320	650	90

#### § 434.513 Occupancy.

513.1 Occupancy schedules are default assumptions. The same assumptions shall be made in computing Design Energy Consumption as were used in calculating the Energy Cost Budget.

513.2 Table 513.2.a, Occupancy Density, establishes the density, in ft<sup>2</sup>/person of conditioned floor area, to be used for each building type. Table 513.2.b, Building Schedule Percentage Multipliers, establishes the percentage

of total occupants in the building by hour of the day for each building type.

TABLE 513.2.a.—OCCUPANCY DENSITY

Building type	Conditioned floor area Ft <sup>2</sup> /person
Assembly .....	50
Office .....	275
Retail .....	300
Warehouse .....	15000
School .....	75

TABLE 513.2.a.—OCCUPANCY DENSITY—Continued

Building type	Conditioned floor area Ft <sup>2</sup> /person
Hotel/Motel .....	250
Restaurant, Health/Institutional .....	100
Multi-family High-rise Residential .....	200
	2 per unit <sup>1</sup>

<sup>1</sup>Heat generation: Btu/h per person: 230 Btu/h per person sensible, and 190 Btu/h per person latent. See Table 513.2.

TABLE 513.2.b.—BUILDING SCHEDULE PERCENTAGE MULTIPLIERS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. ASSEMBLY																									
OCCUPANCY .....	WEEKDAY .....	0	0	0	0	0	0	0	0	20	20	20	20	80	80	80	80	80	80	20	20	20	20	0	0
	SATURDAY .....	0	0	0	0	0	0	0	0	20	20	20	20	60	60	60	60	60	60	60	60	60	60	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	10	10	10	10	10	70	70	70	70	70	70	70	70	70	0	0
ASSEMBLY .....	WEEKDAY .....	0	0	0	0	0	0	40	40	40	75	75	75	75	75	75	75	75	75	75	75	75	75	0	0
	LTNG & RECEP .....	0	0	0	0	0	0	0	30	30	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0
	SUNDAY .....	0	0	0	0	0	0	0	30	30	30	30	30	65	65	65	65	65	65	65	65	65	65	0	0
ASSEMBLY .....	WEEKDAY .....	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
	HVAC .....	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
	SUNDAY .....	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
ASSEMBLY .....	WEEKDAY .....	0	0	0	0	0	0	0	0	0	5	5	35	5	5	5	5	5	0	0	0	0	0	0	0
	SWH .....	0	0	0	0	0	0	0	0	0	5	5	20	0	0	0	0	0	0	65	30	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	5	5	10	0	0	0	0	0	0	65	30	0	0	0	0
2. OFFICE																									
OCCUPANCY .....	WEEKDAY .....	0	0	0	0	0	0	0	10	20	95	95	45	45	95	95	95	95	95	30	10	10	10	0	0
	SATURDAY .....	0	0	0	0	0	0	0	10	10	30	30	30	30	10	10	10	10	10	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OFFICE .....	WEEKDAY .....	0	0	0	0	0	0	10	30	90	90	90	80	90	90	90	90	90	90	30	30	20	20	0	0
	LTNG & RECEP .....	0	0	0	0	0	0	10	30	30	30	30	15	15	15	15	15	15	15	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OFFICE .....	WEEKDAY .....	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off
	HVAC .....	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
	SUNDAY .....	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
OFFICE .....	WEEKDAY .....	0	0	0	0	0	0	0	15	30	35	35	45	55	50	30	30	40	20	20	10	15	5	0	0

TABLE 513.2.b.—BUILDING SCHEDULE PERCENTAGE MULTIPLIERS—Continued

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SWH .....	SATURDAY .....	0	0	0	0	0	0	0	10	10	20	15	20	15	15	10	10	10	0	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. RETAIL																									
OCCUPANCY .....	WEEKDAY .....	0	0	0	0	0	0	0	0	20	20	20	20	80	80	80	80	80	80	20	20	20	20	0	0
	SATURDAY .....	0	0	0	0	0	0	0	0	20	20	20	20	60	60	60	60	60	60	60	60	60	60	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	10	10	10	10	70	70	70	70	70	70	70	70	70	0	0
RETAIL .....	WEEKDAY .....	0	0	0	0	0	0	40	40	40	75	75	75	75	75	75	75	75	75	75	75	75	75	0	0
LTNG & RECEP .....	SATURDAY .....	0	0	0	0	0	0	0	30	30	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0
	SUNDAY .....	0	0	0	0	0	0	0	30	30	30	30	30	65	65	65	65	65	65	65	65	65	65	0	0
RETAIL .....	WEEKDAY .....	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off
HVAC .....	SATURDAY .....	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off
	SUNDAY .....	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off
RETAIL .....	WEEKDAY .....	0	0	0	0	0	0	0	10	20	30	40	55	60	60	45	40	45	45	40	30	30	0	0	0
SWH .....	SATURDAY .....	0	0	0	0	0	0	0	15	20	25	40	50	55	55	45	45	45	45	40	35	25	20	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	10	25	30	35	35	30	30	35	30	20	0	0	0	0	0
	WEEKDAY .....	0	0	0	0	0	0	0	15	70	90	90	90	50	85	85	85	20	0	0	0	0	0	0	0
4. WAREHOUSE																									
OCCUPANCY .....	SATURDAY .....	0	0	0	0	0	0	0	0	20	20	20	20	10	10	10	10	0	0	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAREHOUSE .....	WEEKDAY .....	0	0	0	0	0	0	0	40	70	90	90	90	90	90	90	90	90	0	0	0	0	0	0	0
LTNG & RECEP .....	SATURDAY .....	0	0	0	0	0	0	0	0	10	25	25	10	10	10	10	0	0	0	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAREHOUSE .....	WEEKDAY .....	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off
HVAC .....	SATURDAY .....	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off
	SUNDAY .....	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off
WAREHOUSE .....	WEEKDAY .....	0	0	0	0	0	0	0	5	25	35	35	45	55	50	35	50	15	0	0	0	0	0	0	0
SWH .....	SATURDAY .....	0	0	0	0	0	0	0	0	0	10	10	15	0	0	0	0	0	0	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. SCHOOL																									
OCCUPANCY .....	WEEKDAY .....	.....	.....	.....	0	0	0	0	5	75	90	90	80	80	80	80	45	15	5	15	20	20	10	0	0
	SATURDAY .....	0	0	0	0	0	0	0	0	10	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCHOOL .....	WEEKDAY .....	0	0	0	0	0	0	0	30	85	95	95	80	80	80	70	50	50	35	35	35	30	0	0	0
LTNG&RECEP .....	SATURDAY .....	0	0	0	0	0	0	0	0	15	15	15	15	15	0	0	0	0	0	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCHOOL .....	WEEKDAY .....	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
HVAC .....	SATURDAY .....	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	SUNDAY .....	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
SCHOOL .....	WEEKDAY .....	0	0	0	0	0	0	0	5	30	55	60	70	75	80	60	60	5	5	15	20	20	20	0	0
SWH .....	SATURDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WEEKDAY .....	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	70	70	80	90	90	90
6. HOTEL/MOTEL																									
OCCUPANCY .....	SATURDAY .....	90	90	90	90	90	90	70	50	50	30	30	30	30	30	30	30	30	50	60	60	60	70	70	70
	SUNDAY .....	70	70	70	70	70	70	70	70	50	50	50	30	20	20	20	20	30	40	40	60	60	80	80	80
	WEEKDAY .....	20	15	10	10	10	20	40	50	40	40	25	25	25	25	25	25	25	25	60	80	90	80	60	30
LTNG&RECEP .....	SATURDAY .....	20	20	10	10	10	10	30	30	40	40	30	25	25	25	25	25	25	25	60	70	70	70	60	30
	SUNDAY .....	30	30	20	20	20	20	30	40	40	30	30	30	30	20	20	20	20	50	70	80	60	50	30	30
HOTEL/MOTEL .....	WEEKDAY .....	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
HVAC .....	SATURDAY .....	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	SUNDAY .....	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
HOTEL/MOTEL .....	WEEKDAY .....	20	15	15	15	20	25	50	60	55	45	40	45	40	35	30	30	30	40	55	60	50	55	45	25
SWH .....	SATURDAY .....	20	15	15	15	20	25	40	50	50	50	45	50	50	45	40	40	34	40	55	55	50	55	40	25
	SUNDAY .....	25	20	20	20	20	30	50	50	50	55	50	50	40	40	40	30	30	40	50	50	40	50	40	30
7. RESTAURANT																									
OCCUPANCY .....	WEEKDAY .....	15	15	5	0	0	0	0	5	5	5	20	50	80	70	40	20	25	50	80	80	80	50	35	20
	SATURDAY .....	30	25	5	0	0	0	0	0	5	5	20	45	50	50	35	30	30	30	70	90	70	65	55	35
	SUNDAY .....	20	20	5	0	0	0	0	0	0	0	0	20	25	25	15	20	25	35	55	65	70	35	20	20
RESTAURANT .....	WEEKDAY .....	15	15	15	15	15	20	40	40	60	60	90	90	90	90	90	90	90	90	90	90	90	90	50	30
LTNG & RECEP .....	SATURDAY .....	20	15	15	15	15	15	30	30	60	60	80	80	80	80	80	80	80	90	90	90	90	90	50	30
	SUNDAY .....	20	15	15	15	15	15	30	30	50	70	70	70	70	70	70	70	60	60	60	60	60	60	50	30
RESTAURANT .....	WEEKDAY .....	On	On	On	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
HVAC .....	SATURDAY .....	On	On	On	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	SUNDAY .....	On	On	On	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
RESTAURANT .....	WEEKDAY .....	20	15	15	0	0	0	0	60	55	45	40	45	40	35	30	30	30	40	55	60	50	55	45	25
SWH .....	SATURDAY .....	20	15	15	0	0	0	0	0	0	0	45	50	50	45	40	40	35	40	55	55	50	55	40	30
	SUNDAY .....	25	20	20	0	0	0	0	0	0	0	50	50	40	40	30	30	30	40	50	50	40	50	40	20
	WEEKDAY .....	0	0	0	0	0	0	0	10	50	80	80	80	80	80	80	80	80	50	30	30	20	20	5	0
8. HEALTH																									
OCCUPANCY .....	SATURDAY .....	0	0	0	0	0	0	0	10	30	40	40	40	40	40	40	40	40	10	10	0	0	0	0	0
	SUNDAY .....	0	0	0	0	0	0																		

(2) Table 513.2.1 contains multipliers for converting the nominal values for building occupancy (Table 514.2.1), receptacle power density (Table 516.2) service hot water (Table), and lighting energy (§ 434.515) into time series data for estimating building loads under the Standard Calculation Procedure.

(3) "For each standard building profile there are three series—one each for weekdays, Saturday and Sunday. There are 24 elements per series. These represent the multiplier that should be used to estimate building loads from 12 a.m. to 1 a.m. (series element #1) through 11 p.m. to 12 a.m. (series element #24). The estimated load for any hour is simply the multiplier from the appropriate standard profile multiplied by the appropriate value from the tables cited above."

(4) The Building HVAC System Schedule listed in Table 514.2.2 lists the hours when the HVAC system shall be considered "on" or "off" in accordance with § 434.514."

#### § 434.514 Lighting.

514.1 Interior Lighting Power Allowance (ILPA), for calculating the Energy Cost Budget shall be determined from subsection 401.3.2. The lighting power used to calculate the Design Energy Consumption shall be the actual adjusted power for lighting in the Proposed Design. If the lighting controls in the Proposed Design are more effective at saving energy than those required by subsection 401.3.1 and 401.3.2, the actual installed lighting power shall be used along with the schedules reflecting the action of the controls to calculate the Design Energy Consumption. This actual installed lighting power shall not be adjusted by the Power Adjustment Factors listed in Table 514.1.

TABLE 514.1.—POWER ADJUSTMENT FACTOR (PAF)

Automatic control device(s)	Standard PAF
(1) Occupancy Sensor .....	0.30
(2) Daylight Sensing Continuous Dimming .....	0.30
(3) Daylight Sensing Multiple Step Dimming .....	0.20
(4) Daylight Sensing On/Off .....	0.10
(5) Lumen Maintenance .....	0.10

514.2 Table 513.2.2 establishes default assumptions for the percentage of the lighting load switched-on in each Prototype or Reference Building by hour of the day. These default assumptions can be changed when calculating the Energy Cost Budget to provide, for example, a 12-hour rather than an 8-hour workday.

#### § 434.515 Receptacles.

515.1 Receptacle loads and profiles are default assumptions. The same assumptions shall be made in calculating Design Energy Consumption as were used in calculating the Energy Cost Budget.

515.2 Receptacle loads include all general service loads that are typical in a building. These loads exclude any process electrical usage and HVAC primary or auxiliary electrical usage. Table 515.2, Receptacle Power Densities, establishes the density, in W/ft<sup>2</sup>, to be used for each building type. The receptacle energy profiles shall be the same as the lighting energy profiles

in Table 513.2. This profile establishes the percentage of the receptacle load that is switched on by hour of the day and by building type.

TABLE 515.2.—RECEPTACLE POWER DENSITIES

Building type	W/ft <sup>2</sup> of conditioned floor area
Assembly .....	0.25
Office .....	0.75
Retail .....	0.25
Warehouse .....	0.1
School .....	0.5
Hotel/Motel .....	0.25
Restaurant .....	0.1
Health .....	1.0
Multi-family High Rise Residential ....	( <sup>1</sup> )

<sup>1</sup> Included in Lights and Equipment portions of Table 513.2.

#### § 434.516 Building exterior envelope.

516.1 Insulation and Glazing. The insulation and glazing characteristics of the Prototype and Reference Building envelope shall be determined by using the first column under "Base Case", with no assumed overhangs, for the appropriate Alternate Component Tables (ACP) in Table 402.4.1.2, as defined by climate range. The insulation and glazing characteristics from this ACP are prescribed assumptions for Prototype and Reference Buildings for calculating the Energy Cost Budget. In calculating the Design Energy Consumption of the Proposed Design, the envelope characteristics of the Proposed Design shall be used.

516.2 Infiltration. For Prototype and Reference Buildings, the infiltration assumptions in subsection 516.2.1 shall be prescribed assumptions for calculating the Energy Cost Budget and default assumptions for the Design Energy Consumption. Infiltration shall impact perimeter zones only.

516.2.1 When the HVAC system is switched "on," no infiltration shall be assumed. When the HVAC system is switched "off," the infiltration rate for buildings with or without operable windows shall be assumed to be 0.038 cfm/ft<sup>2</sup> of gross exterior wall. Hotels/motels and multi-family high-rise residential buildings shall have infiltration rates of 0.038 cfm/ft<sup>2</sup> of gross exterior wall area at all times.

516.3 Envelope and Ground Absorptivities. For Prototype and Reference Buildings, absorptivity assumptions shall be prescribed assumptions for computing the Energy Cost Budget and default assumptions for computing the Design Energy Consumption. The solar absorptivity of opaque elements of the building envelope is assumed to be 70%. The solar absorptivity of ground surfaces is assumed to be 80% (20% reflectivity).

516.4 Window Management. For the Prototype and Reference Building, window management drapery assumptions shall be prescribed assumptions for setting the Energy Cost Budget. No draperies shall be the default assumption for computing the Design Energy Consumption. Glazing is assumed to be internally shaded by medium-weight draperies, closed one-half time. The draperies shall be modeled by assuming that one-half the area in each zone is draped and one-half is not. If manually-operated draperies, shades, or blinds are to be used in the Proposed Design, the Design Energy Consumption shall be calculated by assuming they are effective over one-half the glazing area in each zone.

516.5 Shading. For Prototype and Reference buildings and the Proposed Design, shading by permanent structures, terrain, and vegetation shall be taken into account for computing energy consumption, whether or not these features are located on the building site. A permanent fixture is one that is likely to remain for the life of the Proposed Design.

#### § 434.517 HVAC systems and equipment

517.1 The specifications and requirements for the HVAC systems of the Prototype and Reference Buildings shall be those in Table 517.1.1, HVAC Systems for Prototype and Reference Buildings. For the calculation of the Design Energy Consumption, the HVAC systems and equipment of the Proposed Design shall be used.

517.2 The systems and types of energy presented in Table 517.1.1 are assumptions for calculating the Energy Cost Budget. They are not requirements for either systems or the type of energy to be used in the Proposed Building or for the calculation of the Design Energy Cost.

TABLE 517.1.1.—HVAC SYSTEMS OF PROTOTYPE AND REFERENCE BUILDINGS<sup>1,2</sup>

Building/space occupancy	System No. (Table 517.4.1)	Remarks (Table 517.4.1)
Assembly .....	1	
a. Churches (any size) .....	1 or 3 .....	Note 1.
b. ≤50,000 ft <sup>2</sup> or ≤3 floors .....	3	
c. >50,000 ft <sup>2</sup> or >3 floors.		
Office:		
a. ≤20,000 ft <sup>2</sup> .....	1	
b. ≤50,000 ft <sup>2</sup> and either ≤3 floors or ≤75,000 ft <sup>2</sup> .....	4	
c. <75,000 ft <sup>2</sup> or >3 floors .....	5	
Retail:		
a. ≤50,000 ft <sup>2</sup> .....	1 or 3 .....	Note 1.
b. >50,000 ft <sup>2</sup> .....	4 or 5 .....	Note 1.
Warehouse .....	1 .....	Note 1.
School:		
a. ≤75,000 ft <sup>2</sup> or ≤3 floors .....	1	
b. >75,000 ft <sup>2</sup> or >3 floors .....	3	
Hotel/Motel:		
a. ≤3 stories .....	2 or 7 .....	Note 5, 7.
b. >3 stories .....	6 .....	Note 6.
Restaurant .....	1 or 3 .....	Note 1.
Health:		
a. Nursing Home (any size) .....	2 or 7 .....	Note 7.
b. ≤15,000 ft <sup>2</sup> .....	1	
c. >15,000 ft <sup>2</sup> or ≤50,000 ft <sup>2</sup> .....	4 .....	Note 2.
d. >50,000 ft <sup>2</sup> .....	5 .....	Note 2, 3.
Multi-family High Rise Residential >3 stories .....	7	

<sup>1</sup> Space and Service Water Heating budget calculations shall be made using both electricity and natural gas. The Energy Cost Budget shall be the lower of these two calculations. If natural gas is not available at the rate, electricity and #2 fuel oil shall be used for the budget calculations.

<sup>2</sup> The system and energy types presented in this Table are not intended as requirements or recommendations for the proposed design. Floor areas below are the total conditioned floor areas for the listed occupancy type in the building. The number of floors indicated below is the total number of occupied floors for the listed occupancy type.

517.3 HVAC Zones. HVAC zones for calculating the Energy Cost Budget of the Prototype or Reference Building shall consist of at least four perimeter and one interior zones per floor. Prototype Buildings shall have one perimeter zone facing each cardinal direction. The perimeter zones of Prototype and Reference Buildings shall be 15 ft in width, or one-third the narrow dimension of the building, when this dimension is between 30 ft and 45 ft inclusive, or one-half the narrow dimension of the building when this

dimension is less than 30 ft. Zoning requirements shall be a default assumption for calculating the Energy Cost Budget. For multi-family high-rise residential buildings, the prototype building shall have one zone per dwelling unit. The proposed design shall have one zone per unit unless zonal thermostatic controls are provided within units; in this case, two zones per unit shall be modeled. Building types such as assembly or warehouse may be modeled as a single zone if there is only one space.

517.4 For calculating the Design Energy Consumption, no fewer zones shall be used than were in the Prototype and Reference Buildings. The zones in the simulation shall correspond to the zones provided by the controls in the Proposed Design. Thermally similar zones, such as those facing one orientation on different floors, may be grouped together for the purposes of either the Design Energy Consumption or Energy Cost Budget simulation.

TABLE 517.4.1. HVAC SYSTEM DESCRIPTION FOR PROTOTYPE AND REFERENCE BUILDINGS<sup>12</sup>

HVAC COMPONENT	SYSTEM #1	SYSTEM #2	SYSTEM #3	SYSTEM #4	SYSTEM #5	SYSTEM #6	SYSTEM #7
System Description	Packaged rooftop single room, one unit per zone.	Packaged terminal air conditioner with space heater or heat pump, one heating/cooling unit per zone.	Air handler per zone with central plant.	Packaged rooftop VAV w/perimeter reheat.	Built-up central VAV with perimeter reheat.	Fourpipe fan coil per zone with central plant.	Water source pump.
Fan system Design supply circulation.	Note 9 .....	Note 10 .....	Note 9 .....	Note 9 .....	Note 9 .....	Note 9 .....	Note 10.
Supply fan total static pressure.	1.3 in W.C. ....	N/A .....	2.0 in W.C. ....	3.0 in W.C. ....	4.0 in W.C. ....	0.5 in W.C. ....	0.5 in W.C.
Combined supply fan, motor, and drive efficiency.	40% .....	N/A .....	50% .....	45% .....	55% .....	25A .....	25%.

TABLE 517.4.1. HVAC SYSTEM DESCRIPTION FOR PROTOTYPE AND REFERENCE BUILDINGS<sup>12</sup>—Continued

HVAC COMPONENT	SYSTEM #1	SYSTEM #2	SYSTEM #3	SYSTEM #4	SYSTEM #5	SYSTEM #6	SYSTEM #7
Supply fan control	Constant volume.	Fan Cycles with call for heating or cooling.	Constant volume	VAV w/forward curved centrifugal fan and variable inlet vanes.	VAVV w/air-foil centrifugal fan and AC frequency variable speed drive.	Fan Cycles with call for heating or cooling.	Fan cycles w/ call for heating or cooling.
Return fan total static pressure.	N/A .....	N/A .....	0.6 in W.C. ....	0.6 in W.C. ....	1.0 in W.C. ....	N/A .....	N/A.
Combined return fan, motor, and drive efficiency.	N/A .....	N/A .....	25% .....	25% .....	30% .....	N/A .....	N/A.
Return fan control	N/A .....	N/A .....	Constant volume	VAV w/forward curved centrifugal fan and discharge dampers.	VAV with air-foil centrifugal fan and AC frequency variable speed drive.	N/A .....	N/A.
Cooling System .....	Direct expansion air cooled.	Direct expansion air cooled.	Chilled water (Note 1).	Direct expansion air cooled.	Chilled water (Note 11).	Chilled water (Note 11).	Closed circuit, centrifugal blower type cooling tower sized per Note 11. Circulating pump size for 2.7 GPM per ton.
Heating System .....	Furnace, heat pump, or electric resistance (Note 8).	Heat pump w/ electric resistance auxiliary or air conditioner w/ space heater (Note 8).	Hot water (Note 8, 12).	Hot water (Note 12) or electric resistance (Note B).	Hot water (Note 12) or electric resistance (Note 8).	Hot water (Note 12) or electric resistance (Note 8).	Electric or natural draft fossil fuel boiler (Note 8).
Remarks .....	Dry bulb economizer per Section 7.4.3 (barometric relief).	No economizer.	Dry bulb economizer per Section 434.514.	Dry bulb economizer per Section 434.514 Minimum VAV setting per 434.514 exception 1. Supply air reset by zone of greatest cooling demand.	Dry bulb economizer per Section 7.4.3 Minimum VAV setting per Section 7.4.4.3. Supply air reset by zone of greatest cooling demand.	No economizer.	Tower fans and boiler cycled to maintain circulating water temperature between 60 and design tower leaving water temperature.

## Notes:

1. The systems and energy types presented in this Table are not intended as requirements or recommendations for the proposed design.
2. For numbered notes see end of Table 517.4.1.

## Numbered Notes For Table 517.4.1 HVAC System Descriptions for Prototype and Reference Buildings

## NOTES:

1. For occupancies such as restaurants, assembly and retail which are part of a mixed use building which, according to Table 517.4.1, includes a central chilled water plant (systems 3, 5, or 6), chilled water system type 3 or 5, as indicated in the Table, shall be used.

2. Constant volume may be used in zones where pressurization relationships must be maintained by code. VAV shall be used in all other areas, in accordance with § 517.4.

3. Provide run-around heat recovery systems for all fan systems with minimum outside air intake greater than 75%. Recovery effectiveness shall be 0.60.

4. If a warehouse is not intended to be mechanically cooled, both the Energy Cost Budgets and Design Energy Costs, may be calculated assuming no mechanical cooling.

5. The system listed is for guest rooms only. Areas such as public areas and back-of-house areas shall be served by system 4. Other areas such as offices and retail shall be served by the systems listed in Table 517.4.1 for those occupancy types.

6. The system listed is for guest rooms only. Areas such as public areas and back-of-

house areas shall be served by System 5. Other areas such as offices and retail shall be served by the systems listed in Table 517.4.1.1 for those occupancy types.

7. System 2 shall be used for Energy Cost Budget calculation except in areas with design heating outside air temperatures less than 10°F.

8. Prototype energy budget cost calculations shall be made using both electricity and natural gas. If natural gas is not available at the site, electricity and #2 fuel oil shall be used. The Energy Cost Budget shall be the lower of these results. Alternatively, the Energy Cost Budget may be based on the fuel source that minimizes total



operating, maintenance, equipment, and installation costs for the prototype over the building lifetime. Equipment and installation cost estimates shall be prepared using professionally recognized cost estimating tools, guides, and techniques. The methods of analysis shall conform to those of Subpart A of 10 CFR 436. Energy costs shall be based on actual costs to the building as defined in this Section.

9. Design supply air circulation rate shall be based on a supply air to room air temperature differences of 20°F. A higher supply air temperature may be used if required to maintain a minimum circulation rate of 4.5 air changes per hour or 15 cfm per person at design conditions to each zone served by the system. If return fans are specified, they shall be sized from the supply fan capacity less the required minimum ventilation with outside air, or 75% or the supply air capacity, whichever is larger. Except where noted, supply and return fans shall be operated continually during occupied hours.

10. Fan System Energy when included in the efficiency rating of the unit as defined in § 403.2.4.3 need not be modeled explicitly for this system. The fan shall cycle with calls for heating or cooling.

11. Chilled water systems shall be modeled using a reciprocating chiller for systems with total cooling capacities less than 175 tons, and centrifugal chillers for systems with cooling capacities of 175 tons or greater. For systems with cooling or 600 tons or more, the Energy Cost Budget shall be calculated using two centrifugal chillers lead/lag controlled. Chilled water pumps shall be sized using a 12°F temperature rise, from 44°F to 56°F operating at 65 feet of head and 65% combined impeller and motor efficiency. Condenser water pumps shall be sized using a 10°F temperature rise, operating at 60 feet of head and 60% combined impeller and motor efficiency. The cooling tower shall be an open circuit, centrifugal blower type sized for the larger of 85°F leaving water temperature or 10°F approach to design wet bulb temperature. The tower shall be controlled to provide a 65°F leaving water temperature whenever weather conditions permit, floating up to design leaving water temperature at design conditions. Chilled water supply temperature shall be reset in accordance with § 434.518.

12. Hot water system shall include a natural draft fossil fuel or electric boiler per Note 8. The hot water pump shall be sized based on a 30°F temperature drop, for 18°F to 150°F, operating at 60 feet of head and a combined impeller and motor efficiency of 60%. Hot water supply temperature shall be reset in accordance with § 434.518.

**517.5 Equipment Sizing and Redundant Equipment.** For calculating the Energy Cost Budget of Prototype or Reference Buildings, HVAC equipment shall be sized to meet the requirements of subsection 403.2.2, without using any of the exceptions. The size of equipment shall be that required for the building without process loads considered. Redundant or emergency equipment need not be simulated if it is controlled

so that it will not be operated during normal operations of the building. The designer shall document the installation of process equipment and the size of process loads.

**517.6** For calculating the Design Energy Consumption, actual air flow rates and installed equipment size shall be used in the simulation, except that excess capacity provided to meet process loads need not be modeled unless the process load was not modeled in setting Energy Cost Budget. Equipment sizing in the simulation of the Proposed Design shall correspond to the equipment actually selected for the design and the designer shall not use equipment sized automatically by the simulation tool.

**517.6.1** Redundant or emergency equipment need not be simulated if it is controlled to not be operated during normal operations of the building.

#### **§ 434.518 Service water heating.**

**518.1** The service water loads for Prototype and Reference Buildings are defined in terms of Btu/h per person in Table 518.1.1, Service Hot Water Quantities. The service water heating loads from Table 518.1.1 are prescribed assumptions for multi-family high-rise residential buildings and default assumptions for all other buildings. The same service water heating load assumptions shall be made in calculating Design Energy Consumption as were used in calculating the Energy Cost Budget.

**TABLE 518.1.1.—Service Hot Water Quantities**

Building type	Btu/Person-hour <sup>1</sup>
Assembly .....	215
Office .....	175
Retail .....	135
Warehouse .....	225
School .....	215
Hotel/Motel .....	1110
Restaurant .....	390
Health .....	135
Multi-family High Rise Residential .....	≥ 1700

<sup>1</sup> This value is the number to be multiplied by the percentage multipliers of the Building Profile Schedules in Table 513.2.2. See Table 513.2.2 for occupancy levels.

<sup>2</sup> Total hot water use per dwelling unit for each hour shall be 3,400 Btu/h times the multi-family high rise residential building SWH system multiplier from Table 514.2.2.

**518.2** The service water heating system, including piping losses for the Prototype Building, shall be modeled using the methods of the RS-47 using a system that meets all requirements of subsection 404. The service water heating equipment for the Prototype or

Reference Building shall be either an electric heat pump or natural gas, or if natural gas is not available at the site, either an electric heat pump or #2 fuel oil. Exception: If electric resistance service water heating is preferable to an electric heat pump when analyzed according to the criteria of § 434.404 or when service water temperatures exceeding 145°F are required for a particular application, electric resistance water heating may be used.

#### **§ 434.519 Controls**

**519.1** All occupied conditioned spaces in the Prototype, Reference and Proposed Design Buildings in all climates shall be simulated as being both heated and cooled. The assumptions in this subsection are prescribed assumptions. If the Proposed Design does not include equipment for cooling or heating, the Design Energy Consumption shall be determined by the specifications for calculating the Energy Cost Budget as described in Table 517.4.1 HVAC System Description for Prototype and Reference Buildings. Exceptions to 519.1 are as follows:

**519.1.1** If a building is to be provided with only heating or cooling, both the Prototype or Reference Building and the Proposed Design shall be simulated, using the same assumptions. Such an assumption cannot be made unless the building interior temperature meets the comfort criteria of RS-2 at least 98% of the occupied hours during the year.

**519.1.2** If warehouses are not intended to be mechanically cooled, both the Energy Cost Budget and Design Energy Consumption shall be modeled assuming no mechanical cooling; and

**519.1.3** In climates where winter design temperature (97.5% occurrence) is greater than 59°F, space heating need not be modeled.

**519.2** Space temperature controls for the Prototype or Reference Building, except multi-family high-rise residential buildings, shall be set at 70°F for space heating and 75°F for space cooling with a deadband per subsection

**403.2.6.3.** The system shut off during off-hours shall be according to the schedule in Table 515.2, except that the heating system shall cycle on if any space should drop below the night setback setting of 55°F. There shall be no similar setpoint during the cooling season. Lesser deadband ranges may be used in calculating the Design Energy Consumption.

Exceptions to 519.2 are as follows:

(a) Setback shall not be modeled in determining either the Energy Cost Budget or Design Energy Cost if setback is not realistic for the Proposed Design,

such as 24-hour/day operations. Health facilities need not have night setback during the heating season; and

(b) Hotel/motels and multi-family high-rise residential buildings shall have a night setback temperature of 60 °F from 11:00 p.m. to 6:00 a.m. during the heating season; and

(c) If deadband controls are not to be installed, the Design Energy Cost shall be calculated with both heating and cooling thermostat setpoints set to the same value between 70°F and 75°F inclusive, assumed to be constant for the year.

519.2.1 For multi-family buildings, the thermostat schedule for the dwelling units shall be as in Table 519.1.2,

Thermostat Settings for Multi-Family High-rise Buildings. The Prototype Building shall use the single zone schedule. The Proposed Design shall use the two-zone schedule only if zonal thermostatic controls are provided. For Proposed Designs that use heat pumps employing supplementary heat, the controls used to switch on the auxiliary heat source during morning warm-up periods shall be simulated accurately. The thermostat assumptions for multi-family high-rise buildings are prescribed assumptions.

519.3 When providing for outdoor air ventilation in calculating the Energy Cost Budget, controls shall be assumed to close the outside air intake to reduce

the flow of outside air to 0 cfm during setback and unoccupied periods. Ventilation using inside air may still be required to maintain scheduled setback temperature. Outside air ventilation, during occupied periods, shall be as required by RS-41, or the Proposed Design, whichever is greater.

519.4 If humidification is to be used in the Proposed Design, the same level of humidification and system type shall be used in the Prototype or Reference Building. If dehumidification requires subcooling of supply air, then reheat for the Prototype or Reference Building shall be from recovered waste heat such as condenser waste heat.

TABLE 519.1.2.—THERMOSTAT SETTINGS FOR MULTI-FAMILY HIGH-RISE BUILDINGS

Time of day	Single zone dwelling unit		Two zone dwelling unit			
	Heat	Cool	Bedrooms/Bathrooms		Other Rooms	
			Heat	Cool	Heat	Cool
Midnight—6 a.m. ....	60	78	60	78	60	85
6 a.m.—9 a.m. ....	70	78	70	78	70	78
9 a.m.—5 p.m. ....	70	78	60	85	70	78
5 p.m.—11 p.m. ....	70	78	70	78	70	78
11 p.m.—Midnight ....	60	78	60	78	60	78

#### § 434.520 Speculative buildings.

520.1 Lighting. The interior lighting power allowance (ILPA) for calculating the Energy Cost Budget shall be determined from Table 401.3.2a. The Design Energy Consumption may be based on an assumed adjusted lighting power for future lighting improvements.

520.2 The assumption about future lighting power used to calculate the Design Energy Consumption must be documented so that the future installed lighting systems may be in compliance with these standards. Documentation must be provided to enable future lighting systems to use either the Prescriptive method or the Systems Performance method of subsection 401.3

520.3 Documentation for future lighting systems that use subsection 401.3 shall be stated as a maximum adjusted lighting power for the tenant spaces. The adjusted lighting power allowance for tenant spaces shall account for the lighting power provided for the common areas of the building.

520.4 Documentation for future lighting systems that use subsection 401.3 shall be stated as a required lighting adjustment. The required lighting adjustment is the whole building lighting power assumed in order to calculate the Design Energy Consumption minus the ILPA value from Table 401.3.2c that was used to

calculate the Energy Cost Budget. When the required lighting adjustment is less than zero, a complete lighting design must be developed for one or more representative tenant spaces, demonstrating acceptable lighting within the limits of the assumed lighting power allowance.

520.5. HVAC Systems and Equipment. If the HVAC system is not completely specified in the plans, the Design Energy Consumption shall be based on reasonable assumptions about the construction of future HVAC systems and equipment. These assumptions shall be documented so that future HVAC systems and equipment may be in compliance with these standards.

#### § 434.521 The Simulation Tool.

521.1 Annual energy consumption shall be simulated with a multi-zone, 8760 hours per year building energy model. The model shall account for:

521.1.1 The dynamic heat transfer of the building envelope such as solar and internal gains;

521.1.2 Equipment efficiencies as a function of load and climate;

521.1.3 Lighting and HVAC system controls and distribution systems by simulating the whole building;

521.1.4 The operating schedule of the building including night setback during various times of the year; and

521.1.5 Energy consumption information at a level necessary to determine the Energy Cost Budget and Design Energy Cost through the appropriate utility rate schedules.

521.1.6 While the simulation tool should simulate an entire year on an hour by hour basis (8760 hours), programs that approximate this dynamic analysis procedure and provide equivalent results are acceptable.

521.1.7 Simulation tools shall be selected for their ability to simulate accurately the relevant features of the building in question, as shown in the tool's documentation. For example, a single-zone model shall not be used to simulate a large, multi-zone building, and a steady-state model such as the degree-day method shall not be used to simulate buildings when equipment efficiency or performance is significantly affected by the dynamic patterns of weather, solar radiation, and occupancy. Relevant energy-related features shall be addressed by a model such as daylighting, atriums or sunspaces, night ventilation or thermal storage, chilled water storage or heat recovery, active or passive solar systems, zoning and controls of heating and cooling systems, and ground-coupled buildings. In addition, models shall be capable of translating the Design Energy Consumption into energy

cost using actual utility rate schedules with the coincidental electrical demand of a building. Examples of public domain models capable of handling such complex building systems and energy cost translations available in the United States are DOE—2.1C and BLAST 3.0 and in Canada, Energy Systems Analysis Series.

521.1.8 All simulation tools shall use scientifically justifiable documented techniques and procedures for modeling building loads, systems, and equipment. The algorithms used in the program shall have been verified by comparison with experimental measurements, loads, systems, and equipment.

#### **Subpart F—Building Energy Compliance Alternative**

##### **§ 434.601 General.**

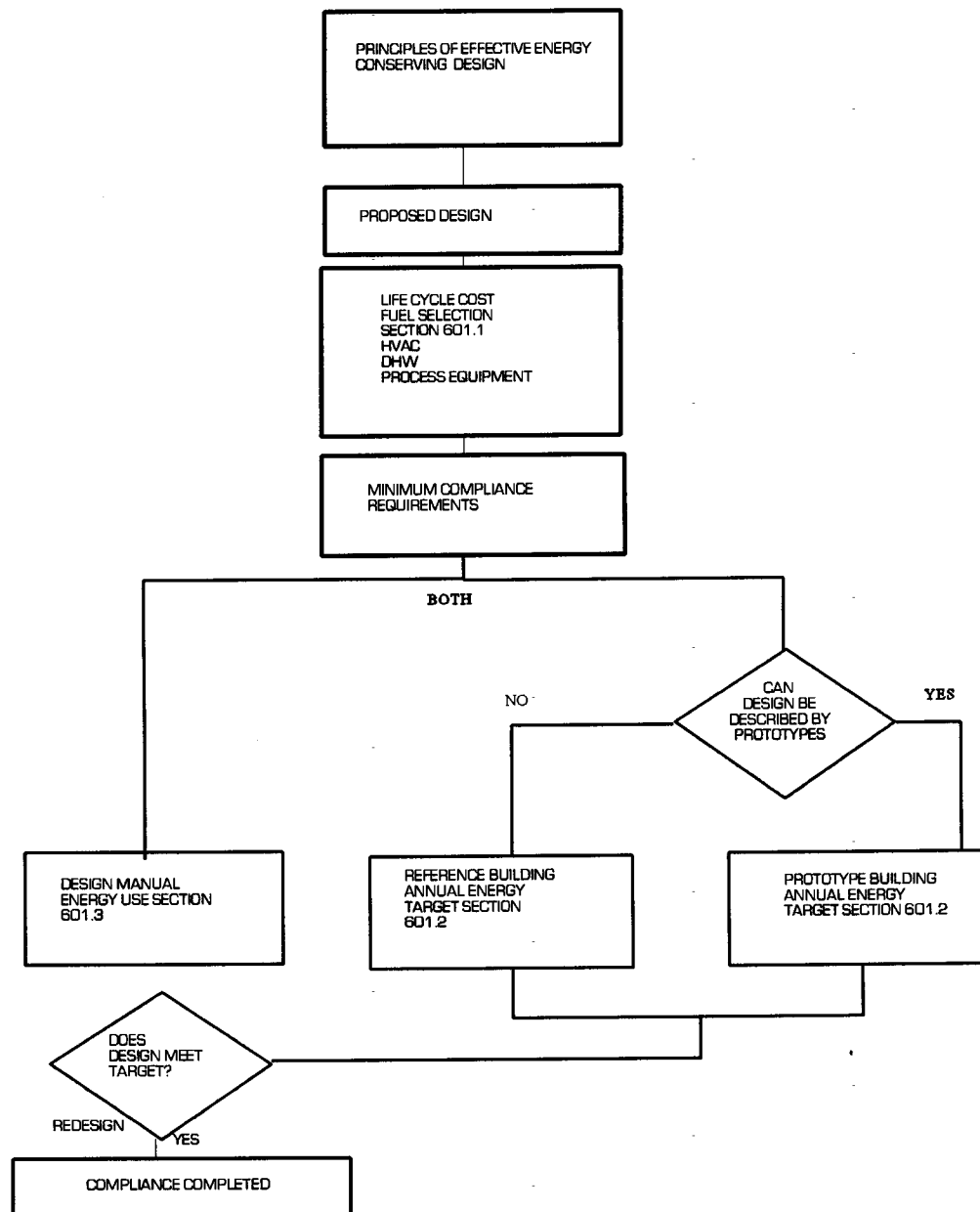
601.1 This subpart provides an alternative path for compliance with the standards that allow for greater flexibility in the design of energy efficient buildings using an annual energy use method. This path provides an opportunity for the use of innovative designs, materials, and equipment such as daylighting, passive solar heating, and heat recovery, that may not be adequately evaluated by methods found in subpart D of this part.

601.2 The Building Energy Compliance Alternative shall be used

with Subpart C and Subpart D, 401.1, 401.2, 401.3.4 and in conjunction with the minimum requirements found in subsections 402.1, 402.2, and 402.3., 403.1, 403.2.1–7, 403.9 and 404.

601.3 Compliance under this section is demonstrated by showing that the calculated annual energy usage for the Proposed Design is less than or equal to a calculated Energy Use Budget. (See Figure 601.3, Building Energy Compliance Alternative). The analytical procedures in this subpart are only for determining design compliance, and are not to be used either to predict, document or verify annual energy consumption.

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**Figure 601.3****Building Energy Compliance Alternative**

601.4 Compliance under the Building Energy Use Budget method requires a detailed energy analysis, using a conventional simulation tool, of the Proposed Design. A life cycle cost analysis shall be used to select the fuel source for the HVAC systems, service hot water, and process loads from available alternatives. The Annual Energy Consumption of the Proposed Design with the life cycle cost-effective fuel selection is calculated to determine the modeled energy consumption, called the Design Energy Use.

601.5 The Design Energy Use is defined as the energy that is consumed within the five foot line of a proposed building per ft<sup>2</sup> over a 24-hour day, 365-day year period and specified operating hours. The calculated Design Energy Use is then compared to a calculated Energy Use Budget.

601.6 Compliance. The Energy Use Budget is determined by calculating the annual energy usage for a Reference or Prototype Building that is configured to comply with the provisions of Subpart E for such buildings, except that the fuel source(s) of the Prototype or Reference Building shall be the same life cycle cost-effective source(s) selected for the Proposed Design. If the Design Energy

Use is less than or equal to the Energy Use Budget then the proposed design complies with these standards.

601.7 This section provides instructions for determining the Design Energy Use and for calculating the Energy Use Budget. The Energy Use Budget is the highest allowable calculated annual energy consumption for a specified building design. Designers are encouraged to design buildings whose Design Energy Use is lower than the Energy Use Budget.

#### § 434.602 Determination of the annual energy budget.

602.1 The Energy Use Budget shall be calculated for the appropriate Prototype or Reference Building in accordance with the procedures prescribed in subsection 502 with the following exceptions: The Energy Use Budget shall be stated in units of Btu/ft<sup>2</sup>/yr and the simulation tool shall segregate the calculated energy consumption by fuel type producing an Energy Use Budget for each fuel (the fuel selections having been made by a life cycle cost analysis in determining the proposed design).

601.2 The Energy Use Budget (EUB) is calculated similarly for the Reference

or Prototype Building using the following equation:

Equation 601.2

$$EUB = EUB_1 x f_1 + EUB_2 x f_2 + EUB_i x f_i$$

Where EUB<sub>1</sub>, EUB<sub>2</sub>, EUB<sub>i</sub> are the calculated annual energy targets for each fuel used in the Reference or Prototype building and f<sub>1</sub>, f<sub>2</sub>, \* \* \* f<sub>i</sub> are the energy conversion factors given in Table 602.2, Fuel Conversion Factors for Computing Design Annual Energy Uses. In lieu of case by case calculation of the Energy Use Budget, the designer may construct Energy Use Budget tables for the combinations of energy source(s) that may be considered in a set of project designs, such as electric heating, electric service water, and gas cooling or oil heating, gas service water and electric cooling. The values in such optional Energy Use Budget tables shall be equal to or less than the corresponding Energy Use Budgets calculated on a case by case basis according to this section. Energy Use Budget tables shall be constructed to correspond to the climatic regions and building types in accordance with provisions for Prototype or Reference Building models in Subpart E of these standards.

TABLE 602.2.—FUEL CONVERSION FACTORS FOR COMPUTING DESIGN ANNUAL ENERGY USES

FUELS	CONVERSION FACTOR
Electricity .....	3412 Btu/kilowatt hour.
Fuel Oil .....	138,700 Btu/gallon.
Natural Gas .....	1,031,000 Btu/1000 ft <sup>3</sup> .
Liquefied Petroleum (including Propane and Butane) .....	95,500 Btu/gallon.
Anthracite Coal .....	28,300,000 Btu/short ton.
Bituminous Coal .....	24,580,000 Btu/short ton.
Purchased Steam and Steam from Central Plants .....	1,000 Btu/Pound.
High Temperature or Medium Temperature Water from Central Plants .....	Use the heat value based on the water actually delivered at the building five foot line

#### NOTE:

At specific locations where the energy source Btu content varies significantly from the value presented above then the local fuel value may be used provided there is supporting documentation from the fuel source supplier stating this actual fuel energy value and verifying that this value will remain consistent for the foreseeable future. The fuel content for fuels not given above shall be determined from the best available source.

#### § 434.603 Determination of the design energy use

603.1 The Design Energy Use shall be calculated by modeling the Proposed Design using the same methods, assumptions, climate data, and simulation tool as were used to establish the Energy Use Budget, but with the design features that will be used in the final building design. The simulation tool used shall segregate the calculated energy consumption by fuel type giving an annual Design Energy Use for each fuel. The sum of the Design Energy Uses multiplied by the fuel conversion factors in Table 602.2 yields the Design Energy Use for the proposed design:

#### Equation 603.1

$$DEU = DEU_1 x f_1 + DEU_2 x f_2 + \dots + DEU_i x f_i$$

Where f<sub>1</sub>, f<sub>2</sub>, . . . f<sub>i</sub> are the fuel conversion factors in Table 602.2.

#### 603.2 Required Life Cycle Cost Analysis for Fuel Selection

603.2.1 Fuel sources selected for the Proposed Design and Prototype or Reference buildings shall be determined by considering the energy cost and other costs and cost savings that occur during the expected economic life of the alternative.

603.2.2 The designer shall use the procedures set forth in Subpart A of 10 CFR Part 436 to make this determination. The fuel selection life

cycle cost analysis shall include the following steps:

603.2.2.1 Determine the feasible alternatives for energy sources of the Proposed Design's HVAC systems, service hot water, and process loads.

603.2.2.2 Model the Proposed Design including the alternative HVAC and service water systems and conduct an annual energy analysis for each fuel source alternative using the simulation tool specified in this section. The annual energy analysis shall be computed on a monthly basis in conformance with Subpart E with the exception that all process loads shall be

included in the calculation. Separate the output of the analysis by fuel type.

603.2.2.3 Determine the unit price of each fuel using information from the utility or other reliable local source. During rapid changes in fuel prices it is recommended that an average fuel price for the previous twelve months be used in lieu of the current price. Calculate the annual energy cost of each energy source alternative in accordance with procedures in subpart E of this part for the Design Energy Cost. Estimate the initial cost of the HVAC and service water systems and other initial costs such as energy distribution lines and service connection fees associated with each fuel source alternative. Estimate other costs and benefits for each alternative including, but not necessarily limited to, annual maintenance and repair, periodic and one time major repairs and replacements and salvage of the energy and service water systems. Cost estimates shall be prepared using professionally recognized cost estimating tools, guides and techniques.

603.2.2.4 Perform a life cycle cost analysis using the procedure specified in subsection 603.2.

603.2.2.5 Compare the total life cycle cost of each energy source alternative. The alternative with the lowest total life cycle cost shall be chosen as the energy source for the proposed design.

#### **§ 434.604 Compliance.**

604.1 Compliance with this section is demonstrated if the Design Energy Use is equal to or less than the Energy Use Budget.

DEU < EUB  
Equation 604

604.2 The energy consumption shall be measured at the building five foot line for all fuels. Energy consumed from non-depletable energy sources and heat recovery systems shall not be included in the Design Energy Use calculations. The thermal efficiency of fixtures,

equipment, systems or plants in the proposed design shall be simulated by the selected calculation tool.

#### **§ 434.605 Standard calculation procedure.**

605.1 The Standard Calculation Procedure consists of methods and assumptions for calculating the Energy Use Budgets for Prototype and Reference Buildings and the Design Energy Use for the Proposed Design. In order to maintain consistency between the Energy Use Budgets and the Design Energy Use, the input assumptions stated in subsection 510.2 are to be used.

605.2 The terms Energy Cost Budget and Design Energy Cost or Design Energy Consumption used in Subpart E of this part correlate to Energy Use Budget and Design Energy Use, respectively, in this Subpart F.

#### **§ 434.606 The simulation tool.**

606.1 The criteria established in subsection 521 for the selection of a simulation tool shall be followed when using the compliance path prescribed in this subpart F.

#### **§ 434.607 Life cycle cost analysis.**

607.1 The following life cycle cost criteria applies to the fuel selection requirements of this subpart and to option life cycle cost analyses performed to evaluate energy conservation design alternatives. The fuel source(s) selection shall be made in accordance with the requirements of subpart A of 10 CFR part 436. When performing optional life cycle cost analyses of energy conservation opportunities the designer may use the life cycle cost procedures of subpart A of 10 CFR part 436 or OMB Circular 1-94 or an equivalent procedure that meets the assumptions listed below:

607.1.1 The economic life of the Prototype Building and Proposed Design shall be 25 years. Anticipated replacements or renovations of energy related features and systems in the Prototype or Reference Building and

Proposed Design during this period shall be included in their respective life cycle cost calculations.

607.1.2 The designer shall follow established professional cost estimating practices when determining the costs and benefits associated with the energy related features of the Prototype or Reference Building and Proposed Design.

607.1.3 All costs shall be expressed in current dollars. General inflation shall be disregarded. Differential escalation of prices (prices estimated to rise faster or slower than general inflation) for energy used in the life cycle cost calculations shall be those in effect at the time of the latest "Annual Energy Outlook" (DOE/EIA-0383) as published by the Department of Energy's Energy Information Administration.

607.1.4 The economic effects of taxes, depreciation and other factors not consistent with the practices of subpart A of 10 CFR part 436 shall not be included in the life cycle cost calculation.

### **Subpart G - Reference Standards**

#### **§ 434.701 Reference standards.**

701.1 General. The standards, technical handbooks, papers, regulations, and portions thereof, that are referred to in the sections and subsections in the following list are hereby incorporated by reference into this part 434. The following standards have been approved for incorporation by reference by the Director of the Federal Register in accordance with 5 U.S.C. 522(a) and 1 CFR part 51. A notice of any change in these materials will be published in the Federal Register. The standards incorporated by reference are available for inspection at the Office of the Federal Register, 800 North Capitol Street, N.W., suite 700, Washington, DC. The following standards are incorporated by reference in this part:

Ref. No.	Standard Designation	Section
RS-1	ASHRAE/IES 90.1-89, Energy Efficient Design of New Buildings Except New Low-Rise Residential Buildings, and Addenda 90.1b, 90.1c, 90.1d, 90.1e, 90.1g, and 90.1i, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA 30329.	301.1
RS-2*	ANSI/ASHRAE 55-92, Thermal Environmental Conditions for Human Occupancy, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA 30329	
RS-3*	NEMA MG1-1993, "Motors and Generators," Revision No. 1, December 7, 1993, National Electrical Manufacturers Association, Washington, DC 20037.	401.1
RS-4	ASHRAE, Handbook, 1989 Fundamentals Volume, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA 30329.	301.1 402.1.1 402.1.2.4
RS-5	ASTM C177-85, Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus, ASTM, Philadelphia, PA 19103.	402.1.1 402.1.2.1 402.1.2.2

Ref. No.	Standard Designation	Section
RS-6	ASTM C518-85, Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, ASTM, Philadelphia, PA 19103.	402.1.1 402.1.2.1 Table 402.1.2.2 Table 403.2.9.2
RS-7	ASTM C236-80, Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box, ASTM, Philadelphia, PA 19103.	402.1.1 402.1.2.1 402.1.2.2
RS-8	ASTM C976-82, Test Method for Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box, ASTM, Philadelphia, PA 19103.	402.1.1 402.1.2.1 402.1.2.2
RS-9	Johannesson, Gudni, "Thermal Bridges in Sheet Metal Construction," Studies in Building Physics, Division of Building Technology, Lund Institute of Technology, Lund, Sweden, Report TVAHB-3007, 1981 (see also FEDERAL REGISTER, Volume 54, No. 18, January 30, 1989, 10 CFR Part 434).	402.1.2.3
RS-10*	ASTM E283-89, Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors, ASTM, Philadelphia, PA 19103.	402.2 402.2.1
RS-11*	ANSI/AAMA 101-88, Aluminum Prime Windows and Sliding Glass Doors, American Architectural Manufacturers Association, Des Plaines, IL 60018.	402.2.1
RS-12*	ASTM D4099-89, Specifications for Poly (Vinyl Chloride) (PVC) Prime Windows, ASTM, Philadelphia, PA 19103.	402.2.1
RS-13*	ANSI/NWWDA I.S.2-93, Wood Window Units, National Wood Window and Door Association (formerly the National Woodwork Manufacturers Association), Des Plaines, IL 60018.	402.2.1
RS-14*	ANSI/NWWDA I.S.3-87, Wood Sliding Patio Doors, National Wood Window and Door Association (formerly the National Woodwork Manufacturers Association), Des Plaines, IL 60018, 1987.	402.2.2.1
RS-15*	ARI Standard 210/240-89, Unitary Air-Conditioning and Air-Source Heat Pump Equipment, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1989. (Addendum 90.1i).	403.1
RS-16	ARI Standard 360-86, Commercial and Industrial Unitary Air-Conditioning Equipment, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1986.	403.1
RS-17	ARI Standard 340-86, Commercial and Industrial Unitary Heat Pump Equipment, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1986.	403.1
RS-18*	ARI 310-90, Packaged Terminal Air-Conditioners, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1990 (Addendum 90.1i).	403.1.
RS-19*	ARI Standard, 380-90, Packaged Terminal Heat Pumps, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1990. (Addendum 90.1i).	403.1
RS-20	Code of Federal Regulations, 10 CFR, Part 430, Appendix N, Uniform Test Method for Measuring the Energy Consumption of Furnaces (49 FR 12159, March 28, 1984, as amended at 54 FR 6076, February 7, 1989; 64 FR 11320, March 17, 1991, U.S. Department of Energy, U.S. Government Printing Office, Washington, DC 20402. (Addendum 90.1b).	403.1
RS-21	ANSI Z21.47-90, Gas-Fired Central Furnaces (Except Direct Vent and Separated Combustion System Furnaces); Addenda Z21.47 A-1985, Addenda Z21.47B-1986, American Gas Association, Cleveland, OH 44131, 1990. (Addendum 90.1b).	403.1
RS-22*	U.L. 727-90, Oil-Fired Central Furnaces, Underwriters Laboratories, Northbrook, IL 60062, 1990. (Addendum 90.1b).	403.1
RS-23	ANSI Z83.9-90, Gas-Fired Duct Furnaces, American Gas Association, Cleveland, OH 44131, 1990. (Addendum 90.1b).	403.1
RS-24	ANSI Z83.8-90, Gas Unit Heaters; Addenda Z83.8A-1986, American Gas Association, Cleveland, OH 44131, 1990. (Addendum 90.1b).	403.1
RS-25	U.L. 731-88, Oil-Fired Unit Heaters (R-1985), Underwriters Laboratories, Northbrook, IL 60062, 1988. (Addendum 90.1b).	403.1
RS-26	CTI Standard—201(86), Certification Standard for Commercial Water Cooling Towers, Cooling Tower Institute, P.O. Box 73383, Houston, TX 77273, 1986.	403.1
RS-27	ARI Standard 320-86, Water-Source Heat Pumps, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1986.	403.1
RS-28	ARI Standard 325-85, Ground Water-Source Heat Pumps, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1985.	403.1
RS-29	ARI Standard 365-87, Commercial and Industrial Unitary Air-Conditioning Condensing Units, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1987.	403.1
RS-30*	ARI Standard 550-90, Centrifugal or Rotary Water-Chilling Packages, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1990.	403.1
RS-31	ARI Standard 590-86, Reciprocating Water-Chilling Packages, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209, 1986.	403.1
RS-32	ANSI Z21.13-87, Gas-Fired Low-Pressure Steam and Hot Water Boilers, Addenda Z21.13A-1983, American Gas Association, Cleveland, OH 44131, 1987. (Addendum 90.1b).	403.1
RS-33	ANSI/U.L., 726-90, Oil-Fired Boiler Assemblies (R-1986), Underwriters Laboratories, Northbrook, IL 60062, 1990. (Addendum 90.1b).	403.1
RS-34	HVAC Duct Construction Standards—Metal and Flexible, 1st Ed., Sheet Metal and Air-Conditioning Contractors Assoc., Vienna, VA 22180, 1985.	403.2.9.3
RS-35	HVAC Duct Leakage Test Manual, 1st Ed., Sheet Metal and Air-Conditioning Contractors Assoc., Vienna, VA 22180, 1985.	403.2.9.3 403.1
RS-36	Fibrous Glass Duct Construction Standard, 5th Ed., Sheet Metal and Air-Conditioning Contractors Assoc., Vienna, VA 22180, 1979.	403.2.9.3
RS-37	Code of Federal Regulations 10 CFR, Part 430, Subpart B, Appendix E, Uniform Test Method for Measuring the Energy Consumption of Water Heaters (55 FR 42619, October 17, 1990), U.S. Government Printing Office, Washington, D.C. 20402.	Table 404.1
RS-38	ANSI Z21.56-89, Gas Fired Pool Heaters, American Gas Association, Cleveland, OH 44131, 1989 .....	Table 404.1

Ref. No.	Standard Designation	Section
RS-39	ANSI Z21.10.3-1990, Gas Water Heaters, Volume III, Storage with Input Ratings above 75,000 Btu's per Hour, Circulating and Instantaneous Water Heaters, American Gas Association, Cleveland, OH 44131, 1990.	404.1
RS-40	ANSI/AHAM RAC-1-1982, Room Air Conditioners, Association of Home Appliance Manufacturers, Chicago, IL 60606, 1982.	404.1.1
RS-41	ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA 30329, 1989.	403.1
RS-42	ANSI Z21.66-1988, Automatic Vent Damper Devices for Use with Gas-Fired Appliances, 1988 .....	403.2.4
RS-43	NEMA MG 10-1983 (R 1988), Energy Management Guide for Selection and Use of Polyphase Motors, National Electric Manufacturers Association, Washington, DC, 20037.	404.1
RS-44	NEMA MG 11-1977 (R 1982, 1987), Energy Management Guide for Selection and Use of Single-Phase Motors, National Electrical Manufacturers Association, Washington, DC 20037.	
RS-45	ARI Standard 330-93, Ground-Source Closed Loop Heat Pumps, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209.	403.1
RS-46	ARI Standard 560-92, Absorption Water Chilling and Water Heating Packages, Air-Conditioning and Refrigeration Institute, Arlington, VA 22209.	403.1
RS-47	ASHRAE, Handbook, 1991 Applications Volume, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA 30329..	
RS-48	ASHRAE, Handbook, 1993 Fundamentals Volume, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA 30329.	
RS-49	Codified Version of ASHRAE Standard 90.1-1989, Energy Code for Commercial and High Rise Residential Buildings, including addenda b, c, d, e, g, and i	

#### Example Alternate Component Package Tables

The example Alternate Component Package tables illustrate the requirements of subsections 301.1, 402.3.1., 402.3.2, 402.4.1.1 and

402.4.1.2. Copies of specific tables contained in this example can be obtained from the Energy Code for Federal Commercial Buildings, Docket No. EE-RM-79-112-C, Buildings Division, EE-432, Office of Codes and

Standards, U.S. Department of Energy, Room 1J-018, 1000 Independence Avenue, S.W., Washington, D.C. 20585, (202) 586-0517.

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