$$LCL_2 = SSD(m_1) - tSE(\bar{X}_2) \quad [9]$$

where t has the value obtained in (5) and $SSD(m_1)$ is sample size discount determined in (4), and compare the combined sample mean (X_2) to the lower control limit (LCL_2) to determine one of the following:

(i) If the mean of the combined sample (X_2) is less than the lower control limit (LCL_2), the basic model is not compliant and testing is at an end.

(ii) If the mean of the combined sample (X_2) is equal to or greater than the lower control limit (LCL_2), the basic model is in compliance and testing is at an end.

[76 FR 12451, Mar. 7, 2011; 76 FR 24781, May 2, 2011]

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

Subpart A—General Provisions

Sec.

Subpart B—Test Procedures

AUTHORITY: 42 U.S.C. 6291–6309; 28 U.S.C. 2461 note.

SOURCE: 42 FR 27898, June 1, 1977, unless otherwise noted.

Subpart A—General Provisions

§ 430.1 Purpose and scope.

This part establishes the regulations for the implementation of part B of title III (42 U.S.C. 6291–6309) of the Energy Policy and Conservation Act (Pub. L. 94–163), as amended by Pub. L. 95–619, Pub. L. 100–12, Pub. L. 100–357, and Pub. L. 102–486 which establishes an energy conservation program for consumer products other than automobiles.

[62 FR 29237, May 29, 1997]

§ 430.2 Definitions.

For purposes of this part, words shall be defined as provided for in section 321 of the Act and as follows—

3-Way incandescent lamp means an incandescent lamp that—

(1) Employs two filaments, operated separately and in combination, to provide three light levels; and

(2) Is designated on the lamp packaging and marketing materials as being a 3-way incandescent lamp.

Act means the Energy Policy and Conservation Act of 1975, as amended, 42 U.S.C. 6291–6316.

Active mode means the condition in which an energy-using product—

(1) Is connected to a main power source;

(2) Has been activated; and

(3) Provides one or more main functions.

Annual fuel utilization efficiency means the efficiency descriptor for furnaces and boilers, determined using test procedures prescribed under section 323 and based on the assumption that all—

(a) Weatherized warm air furnaces or boilers are located out-of-doors;

(b) Warm air furnaces which are not weatherized are located indoors and all combustion and ventilation air is admitted through grill or ducts from the outdoors and does not communicate with air in the conditioned space;

(c) Boilers which are not weatherized are located within the heated space.

ANSI means the American National Standards Institute.

Appliance lamp means any lamp that—

(1) Is specifically designed to operate in a household appliance, has a maximum wattage of 40 watts, is sold at retail (including an oven lamp, refrigerator lamp, and vacuum cleaner lamp); and

(2) Is designated and marketed for the intended application, with

(i) The designation on the lamp packaging; and

(ii) Marketing materials that identify the lamp as being for appliance use.

ARM/simulation adjustment factor means a factor used as part of a DOE-approved alternative rating method (ARM) to improve the accuracy of the calculated ratings for untested split-system central air conditioners or heat pumps. The adjustment factor associated with each outdoor unit must be set such that it reduces the difference between the SEER (HSPF) determined using the ARM and a split-system combination tested in accordance with §430.24(m)(1). The ARM/simulation adjustment factor is an integral part of the ARM and must be a DOE-approved element in accordance with 10 CFR 430.24(m)(4) to (m)(6).

ASME means the American Society of Mechanical Engineers.

Automatic clothes washer means a class of clothes washer which has a control system which is capable of scheduling a preselected combination of operations, such as regulation of water temperature, regulation of the water fill level, and performance of wash, rinse, drain, and spin functions without the need for user intervention subsequent to the initiation of machine operation. Some models may require user intervention to initiate these different segments of the cycle after the machine has begun operation, but they do not require the user to intervene to regulate the water temperature by adjusting the external water faucet valves.

Ballast means a device used with an electric discharge lamp to obtain necessary circuit conditions (voltage, current, and waveform) for starting and operating.

Ballast efficacy factor means the relative light output divided by the power input of a fluorescent lamp ballast, as measured under test conditions specified in ANSI Standard C82.2–1984.

Baseboard electric heater means an electric heater which is intended to be recessed in or surface mounted on walls at floor level, which is characterized by long, low physical dimensions, and which transfers heat by natural convection and/or radiation.

Basic model means all units of a given type of covered product (or class thereof) manufactured by one manufacturer, having the same primary energy source, and which have essentially identical electrical, physical, and functional (or hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency; and

(1) With respect to general service fluorescent lamps, general service incandescent lamps, and incandescent reflector lamps: Lamps that have essentially identical light output and electrical characteristics—including lumens per watt (lm/W) and color rendering index (CRI).

(2) With respect to faucets and showerheads: Have the identical flow control mechanism attached to or installed within the fixture fittings, or the identical water-passage design features that use the same path of water in the highest flow mode.

Batch means a collection of production units of a basic model from which a batch sample is selected.

Batch sample means the collection of units of the same basic model from which test units are selected.

Batch sample size means the number of units in a batch sample.

Batch size means the number of units in a batch.

Battery charger means a device that charges batteries for consumer products, including battery chargers embedded in other consumer products.

Blowout has the meaning given such a term in ASME A112.19.2M–1995. (see § 430.22)

BPAR incandescent reflector lamp means a reflector lamp as shown in figure C78.21–278 on page 32 of ANSI C78.21–2003 (incorporated by reference; *see* § 430.3).

BR30 means a BR incandescent reflector lamp with a diameter of 30/8ths of an inch.

BR40 means a BR incandescent reflector lamp with a diameter of 40/8ths of an inch.

BR incandescent reflector lamp means a reflector lamp that has—

(1) A bulged section below the major diameter of the bulb and above the approximate baseline of the bulb, as shown in figure 1 (RB) on page 7 of ANSI C79.1–1994, (incorporated by reference, see § 430.3); and

(2) A finished size and shape shown in ANSI C78.21–1989 (incorporated by reference; see § 430.3), including the referenced reflective characteristics in part 7 of ANSI C78.21–1989.

BR incandescent reflector lamp means a reflector lamp that has a bulged section below the bulb's major diameter and above its approximate base line as shown in Figure 1 (RB) on page 7 of ANSI C79.1–1994. A BR30 lamp has a lamp wattage of 85 or less than 66 and a BR40 lamp has a lamp wattage of 120 or less.

Btu means British thermal unit, which is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Built-in refrigerator/refrigerator-freezer/freezer means any refrigerator, refrigerator-freezer or freezer with 7.75 cubic feet or greater total volume and 24 inches or less depth not including doors, handles, and custom front panels; with sides which are not finished and not designed to be visible after installation; and that is designed, intended, and marketed exclusively (1) To be installed totally encased by cabinetry or panels that are attached during installation, (2) to be securely fastened to adjacent cabinetry, walls or floor, and (3) to either be equipped with an integral factory-finished face or accept a custom front panel.

Candelabra base incandescent lamp means a lamp that uses a candelabra screw base as described in ANSI C81.61, Specifications for Electric Bases, common designations E11 and E12 (incorporated by reference; see § 430.3).

Casement-only means a room air conditioner designed for mounting in a casement window with an encased assembly with a width of 14.8 inches or less and a height of 11.2 inches or less.

Casement-slider means a room air conditioner with an encased assembly designed for mounting in a sliding or casement window with a width of 15.5 inches or less.

Ceiling electric heater means an electric heater which is intended to be recessed in, surface mounted on, or hung from a ceiling, and which transfers heat by radiation and/or convection (either natural or forced).

Ceiling fan means a nonportable device that is suspended from a ceiling for circulating air via the rotation of fan blades.

Ceiling fan light kit means equipment designed to provide light from a ceiling fan that can be—

(1) Integral, such that the equipment is attached to the ceiling fan prior to the time of retail sale; or

(2) Attachable, such that at the time of retail sale the equipment is not physically attached to the ceiling fan, but may be included inside the ceiling fan at the time of sale or sold separately for subsequent attachment to the fan.

Central air conditioner means a product, other than a packaged terminal air conditioner, which is powered by single phase electric current, air cooled, rated below 65,000 Btu per hour, not contained within the same cabinet as a furnace, the rated capacity of which is above 225,000 Btu per hour, and is a heat pump or a cooling unit only.

Central system humidifier means a class of humidifier designed to add moisture into the air stream of a heating system.

Class A external power supply—

(1) Means a device that—

(i) Is designed to convert line voltage AC input into lower voltage AC or DC output;

(ii) Is able to convert to only one AC or DC output voltage at a time;

(iii) Is sold with, or intended to be used with, a separate end-use product that constitutes the primary load;

(iv) Is contained in a separate physical enclosure from the end-use product;

(v) Is connected to the end-use product via a removable or hard-wired male/female electrical connection, cable, cord, or other wiring; and

(vi) Has nameplate output power that is less than or equal to 250 watts;

(2) But, does not include any device that—

(i) Requires Federal Food and Drug Administration listing and approval as a medical device in accordance with section 513 of the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 360(c)); or

(ii) Powers the charger of a detachable battery pack or charges the battery of a product that is fully or primarily motor operated.

Clothes washer means a consumer product designed to clean clothes, utilizing a water solution of soap and/or detergent and mechanical agitation or other movement, and must be one of the following classes: automatic clothes washers, semi-automatic clothes washers, and other clothes washers.

Coil family means a group of coils with the same basic design features that affect the heat exchanger performance. These features are the basic configuration, i.e., A-shape, V-shape, slanted or flat top, the heat transfer surfaces on refrigerant and air sides (flat tubes vs. grooved tubes, fin shapes), the tube and fin materials, and the coil circuitry. When a group of coils has all these features in common, it constitutes a ''coil family.''

Cold temperature fluorescent lamp means a fluorescent lamp specifically designed to start at −20 °F when used with a ballast conforming to the requirements of ANSI C78.81 (incorporated by reference; see § 430.3) and ANSI C78.901 (incorporated by reference; see § 430.3), and is expressly designated as a cold temperature lamp both in markings on the lamp and in marketing materials, including catalogs, sales literature, and promotional material.

Colored fluorescent lamp means a fluorescent lamp designated and marketed as a colored lamp and not designed or marketed for general illumination applications with either of the following characteristics:

(1) A CRI less than 40, as determined according to the method set forth in CIE Publication 13.3 (incorporated by reference; *see* § 430.3); or

(2) A correlated color temperature less than 2,500K or greater than 7,000K as determined according to the method set forth in IESNA LM–9 (incorporated by reference; *see* § 430.3).

Colored incandescent lamp means an incandescent lamp designated and marketed as a colored lamp that has—

(1) A color rendering index of less than 50, as determined according to the test method given in CIE 13.3 (incorporated by reference; see § 430.3); or

(2) A correlated color temperature of less than 2,500K, or greater than 4,600K, where correlated temperature is computed according to the ''Computation of Correlated Color Temperature and Distribution Temperature,'' Journal of the Optical Society of America, (incorporated by reference; see § 430.3).

Color Rendering Index or CRI means the measured degree of color shift objects undergo when illuminated by a light source as compared with the color of those same objects when illuminated by a reference source of comparable color temperature.

Color television set means an electrical device designed to convert incoming broadcast signals into color television pictures and associated sound.

Compact refrigerator/refrigerator-freezer/freezer means any refrigerator, refrigerator-freezer or freezer with total volume less than 7.75 cubic foot (220 liters) (rated volume as determined in appendices A1 and B1 of subpart B of this part before appendices A and B become mandatory and as determined in appendices A and B of this subpart once appendices A and B become mandatory (see the notes at the beginning of appendices A and B)).

Condenser-evaporator coil combination means a condensing unit made by one manufacturer and one of several evaporator coils, either manufactured by the same manufacturer or another manufacturer, intended to be combined with that particular condensing unit.

Condensing unit means a component of a central air conditioner which is designed to remove the heat absorbed by the refrigerant and to transfer it to the outside environment, and which consists of an outdoor coil, compressor(s), and air moving device.

Consumer product means any article (other than an automobile, as defined in Section 501(1) of the Motor Vehicle Information and Cost Savings Act):

(1) Of a type—

(i) Which in operation consumes, or is designed to consume, energy or, with respect to showerheads, faucets, water closets, and urinals, water; and

(ii) Which, to any significant extent, is distributed in commerce for personal use or consumption by individuals;

(2) Without regard to whether such article of such type is in fact distributed in commerce for personal use or consumption by an individual, except that such term includes fluorescent lamp ballasts, general service fluorescent lamps, incandescent reflector lamps, showerheads, faucets, water closets, and urinals distributed in commerce for personal or commercial use or consumption.

Conventional cooking top means a class of kitchen ranges and ovens which is a household cooking appliance consisting of a horizontal surface containing one or more surface units which include either a gas flame or electric resistance heating.

Conventional oven means a class of kitchen ranges and ovens which is a household cooking appliance consisting of one or more compartments intended for the cooking or heating of food by means of either a gas flame or electric resistance heating. It does not include portable or countertop ovens which use electric resistance heating for the cooking or heating of food and are designed for an electrical supply of approximately 120 volts.

Conventional range means a class of kitchen ranges and ovens which is a household cooking appliance consisting of a conventional cooking top and one or more conventional ovens.

Convertible cooking appliance means any kitchen range and oven which is a household cooking appliance designed by the manufacturer to be changed in service from use with natural gas to use with LP-gas, and vice versa, by incorporating in the appliance convertible orifices for the main gas burners and a convertible gas pressure regulator.

Cooking products means consumer products that are used as the major household cooking appliances. They are designed to cook or heat different types of food by one or more of the following sources of heat: gas, electricity, or microwave energy. Each product may consist of a horizontal cooking top containing one or more surface units and/or one or more heating compartments. They must be one of the following classes: conventional ranges, conventional cooking tops, conventional ovens, microwave ovens, microwave/conventional ranges and other cooking products.

Correlated color temperature means the absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source.

Covered product means a consumer product:

(1) Of a type specified in section 322 of the Act, or

(2) That is a ceiling fan, ceiling fan light kit, medium base compact fluorescent lamp, dehumidifier, battery charger, external power supply, or torchiere.

Dehumidifier means a self-contained, electrically operated, and mechanically refrigerated encased assembly consisting of—

(1) A refrigerated surface (evaporator) that condenses moisture from the atmosphere;

(2) A refrigerating system, including an electric motor;

(3) An air-circulating fan; and

(4) Means for collecting or disposing of the condensate.

Design voltage with respect to an incandescent lamp means:

(1) The voltage marked as the intended operating voltage;

(2) The mid-point of the voltage range if the lamp is marked with a voltage range; or

(3) 120 V if the lamp is not marked with a voltage or voltage range.

Detachable battery means a battery that is—

(1) Contained in a separate enclosure from the product; and

(2) Intended to be removed or disconnected from the product for recharging.

Direct heating equipment means vented home heating equipment and unvented home heating equipment.

Direct vent system means a system supplied by a manufacturer which provides outdoor air or air from an unheated space (such as an attic or crawl space) directly to a furnace or vented heater for combustion and for draft relief if the unit is equipped with a draft control device.

Dishwasher means a cabinet-like appliance which with the aid of water and detergent, washes, rinses, and dries (when a drying process is included) dishware, glassware, eating utensils, and most cooking utensils by chemical, mechanical and/or electrical means and discharges to the plumbing drainage system.

DOE means the Department of Energy.

Electric boiler means an electrically powered furnace designed to supply low pressure steam or hot water for space heating application. A low pressure steam boiler operates at or below 15 pounds per square inch gauge (psig) steam pressure; a hot water boiler operates at or below 160 psig water pressure and 250 °F. water temperature.

Electric central furnace means a furnace designed to supply heat through a system of ducts with air as the heating medium, in which heat is generated by one or more electric resistance heating elements and the heated air is circulated by means of a fan or blower.

Electric clothes dryer means a cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is electricity and the drum and blower(s) are driven by an electric motor(s).

Electric heater means an electric appliance in which heat is generated from electrical energy and dissipated by convection and radiation and includes baseboard electric heaters, ceiling electric heaters, floor electric heaters, portable electric heaters, and wall electric heaters.

Electric refrigerator means a cabinet designed for the refrigerated storage of food, designed to be capable of achieving storage temperatures above 32 °F (0 °C) and below 39 °F (3.9 °C), and having a source of refrigeration requiring single phase, alternating current electric energy input only. An electric refrigerator may include a compartment for the freezing and storage of food at temperatures below 32 °F (0 °C), but does not provide a separate low temperature compartment designed for the freezing and storage of food at temperatures below 8 °F (−13.3 °C).

Electric refrigerator-freezer means a cabinet which consists of two or more compartments with at least one of the compartments designed for the refrigerated storage of food and designed to be capable of achieving storage temperatures above 32 °F (0 °C) and below 39 °F (3.9 °C), and with at least one of the compartments designed for the freezing and storage of food at temperatures below 8 °F (−13.3 °C) which may be adjusted by the user to a temperature of 0 °F (−17.8 °C) or below. The source of refrigeration requires single phase, alternating current electric energy input only.

Electromechanical hydraulic toilet means any water closet that utilizes electrically operated devices, such as, but not limited to, air compressors, pumps, solenoids, motors, or macerators in place of or to aid gravity in evacuating waste from the toilet bowl.

Electronic ballast means a device that uses semiconductors as the primary means to control lamp starting and operation.

Energy conservation standard means any standards meeting the definitions of that term in 42 U.S.C. 6291(6) and 42 U.S.C. 6311(18) as well as any other water conservation standards and design requirements found in this part or parts 430 or 431.

Energy use of a type of consumer product which is used by households means the energy consumed by such product within housing units occupied by households (such as energy for space heating and cooling, water heating, the operation of appliances, or other activities of the households), and includes energy consumed on any property that is contiguous with a housing unit and that is used primarily by the household occupying the housing unit (such as energy for exterior lights or heating a pool).

ER incandescent reflector lamp means a reflector lamp that has—

(1) An elliptical section below the major diameter of the bulb and above the approximate baseline of the bulb, as shown in figure 1 (RE) on page 7 of ANSI C79.1–1994, (incorporated by reference; see § 430.3); and

(2) A finished size and shape shown in ANSI C78.21–1989, (incorporated by reference; see § 430.3).

ER30 means an ER incandescent reflector lamp with a diameter of 30/8ths of an inch.

ER40 means an ER incandescent reflector lamp with a diameter of 40/8ths of an inch.

Estimated annual operating cost means the aggregate retail cost of the energy which is likely to be consumed annually, and in the case of showerheads, faucets, water closets, and urinals, the aggregate retail cost of water and wastewater treatment services likely to be incurred annually, in representative use of a consumer product, determined in accordance with Section 323 of EPCA (42 U.S.C. 6293).

Evaporator coil means a component of a central air conditioner which is designed to absorb heat from an enclosed space and transfer the heat to a refrigerant.

External power supply means an external power supply circuit that is used to convert household electric current into DC current or lower-voltage AC current to operate a consumer product.

External power supply design family means a set of external power supply basic models, produced by the same manufacturer, which share the same circuit layout, output power, and output cord resistance, but differ in output voltage.

Faucet means a lavatory faucet, kitchen faucet, metering faucet, or replacement aerator for a lavatory or kitchen faucet.

Floor electric heater means an electric heater which is intended to be recessed in a floor, and which transfers by radiation and/or convection (either natural or forced).

Fluorescent lamp means a low pressure mercury electric-discharge source in which a fluorescing coating transforms some of the ultraviolet energy generated by the mercury discharge into light, including only the following:

(1) Any straight-shaped lamp (commonly referred to as 4-foot medium bipin lamps) with medium bipin bases of nominal overall length of 48 inches and rated wattage of 25 or more;

(2) Any U-shaped lamp (commonly referred to as 2-foot U-shaped lamps) with medium bipin bases of nominal overall length between 22 and 25 inches and rated wattage of 25 or more;

(3) Any rapid start lamp (commonly referred to as 8-foot high output lamps) with recessed double contact bases of nominal overall length of 96 inches;

(4) Any instant start lamp (commonly referred to as 8-foot slimline lamps) with single pin bases of nominal overall length of 96 inches and rated wattage of 52 or more;

(5) Any straight-shaped lamp (commonly referred to as 4-foot miniature bipin standard output lamps) with miniature bipin bases of nominal overall length between 45 and 48 inches and rated wattage of 26 or more; and

(6) Any straight-shaped lamp (commonly referred to 4-foot miniature bipin high output lamps) with miniature bipin bases of nominal overall length between 45 and 48 inches and rated wattage of 49 or more.

Fluorescent lamp ballast means a device which is used to start and operate fluorescent lamps by providing a starting voltage and current and limiting the current during normal operation.

Flushometer tank means a device whose function is defined in flushometer valve, but integrated within an accumulator vessel affixed and adjacent to the fixture inlet so as to cause an effective enlargement of the supply line immediately before the unit.

Flushometer valve means a valve attached to a pressurized water supply pipe and so designed that when actuated, it opens the line for direct flow into the fixture at a rate and quantity to properly operate the fixture, and then gradually closes to provide trap reseal in the fixture in order to avoid water hammer. The pipe to which this device is connected is in itself of sufficient size, that when open, will allow the device to deliver water at a sufficient rate of flow for flushing purposes.

Forced air central furnace means a gas or oil burning furnace designed to supply heat through a system of ducts with air as the heating medium. The heat generated by combustion of gas or oil is transferred to the air within a casing by conduction through heat exchange surfaces and is circulated through the duct system by means of a fan or blower.

Freezer means a cabinet designed as a unit for the freezing and storage of food at temperatures of 0 °F. or below, and having a source of refrigeration requiring single phase, alternating current electric energy input only.

Furnace means a product which utilizes only single-phase electric current, or single-phase electric current or DC current in conjunction with natural gas, propane, or home heating oil, and which—

(a) Is designed to be the principal heating source for the living space of a residence;

(b) Is not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btu per hour;

(c) Is an electric central furnace, electric boiler, forced-air central furnace, gravity central furnace, or low pressure steam or hot water boiler; and

(d) Has a heat input rate of less than 300,000 Btu per hour for electric boilers and low pressure steam or hot water boilers and less than 225,000 Btu per hour for forced-air central furnaces, gravity central furnaces, and electric central furnaces, gravity central furnaces, and electric central furnaces.

Gas means either natural gas or propane.

Gas clothes dryer means a cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is gas and the drum and blower(s) are driven by an electric motor(s).

General lighting application means lighting that provides an interior or exterior area with overall illumination.

General service fluorescent lamp means any fluorescent lamp which can be used to satisfy the majority of fluorescent lighting applications, but does not include any lamp designed and marketed for the following nongeneral application:

(1) Fluorescent lamps designed to promote plant growth;

(2) Fluorescent lamps specifically designed for cold temperature applications;

(3) Colored fluorescent lamps;

(4) Impact-resistant fluorescent lamps;

(5) Reflectorized or aperture lamps;

(6) Fluorescent lamps designed for use in reprographic equipment;

(7) Lamps primarily designed to produce radiation in the ultra-violet region of the spectrum; and

(8) Lamps with a Color Rendering Index of 87 or greater.

General service incandescent lamp means a standard incandescent or halogen type lamp that is intended for general service applications; has a medium screw base; has a lumen range of not less than 310 lumens and not more than 2,600 lumens; and is capable of being operated at a voltage range at least partially within 110 and 130 volts; however this definition does not apply to the following incandescent lamps—

(1) An appliance lamp;

(2) A black light lamp;

(3) A bug lamp;

(4) A colored lamp;

(5) An infrared lamp;

(6) A left-hand thread lamp;

(7) A marine lamp;

(8) A marine signal service lamp;

(9) A mine service lamp;

(10) A plant light lamp;

(11) A reflector lamp;

(12) A rough service lamp;

(13) A shatter-resistant lamp (including a shatter-proof lamp and a shatter-protected lamp);

(14) A sign service lamp;

(15) A silver bowl lamp;

(16) A showcase lamp;

(17) A 3-way incandescent lamp;

(18) A traffic signal lamp;

(19) A vibration service lamp;

(20) A G shape lamp (as defined in ANSI C78.20) (incorporated by reference; *see* § 430.3) and ANSI C79.1–2002 (incorporated by reference; *see* § 430.3) with a diameter of 5 inches or more;

(21) A T shape lamp (as defined in ANSI C78.20) (incorporated by reference; *see* § 430.3) and ANSI C79.1–2002 (incorporated by reference; *see* § 430.3) and that uses not more than 40 watts or has a length of more than 10 inches; and

(22) A B, BA, CA, F, G16–1/2, G–25, G30, S, or M–14 lamp (as defined in ANSI C79.1–2002) (incorporated by reference; *see* § 430.3) and ANSI C78.20 (incorporated by reference; *see* § 430.3) of 40 watts or less.

General service lamp includes general service incandescent lamps, compact fluorescent lamps, general service light-emitting diode lamps, organic light-emitting diode lamps, and any other lamps that the Secretary determines are used to satisfy lighting applications traditionally served by general service incandescent lamps; however, this definition does not apply to any lighting application or bulb shape excluded from the "general service incandescent lamp" definition, or any general service fluorescent lamp or incandescent reflector lamp.

Gravity central furnace means a gas fueled furnace which depends primarily on natural convection for circulation of heated air and which is designed to be used in conjunction with a system of ducts.

Heat pump means a product, other than a packaged terminal heat pump, which consists of one or more assemblies, powered by single phase electric current, rated below 65,000 Btu per hour, utilizing an indoor conditioning coil, compressor, and refrigerant-to-outdoor air heat exchanger to provide air heating, and may also provide air cooling, dehumidifying, humidifying circulating, and air cleaning.

Home heating equipment, not including furnaces means vented home heating equipment and unvented home heating equipment.

Household means an entity consisting of either an individual, a family, or a group of unrelated individuals, who reside in a particular housing unit. For the purpose of this definition:

(1) *Group quarters* means living quarters that are occupied by an institutional group of 10 or more unrelated persons, such as a nursing home, military barracks, halfway house, college dormitory, fraternity or sorority house, convent, shelter, jail or correctional institution.

(2) *Housing unit* means a house, an apartment, a group of rooms, or a single room occupied as separate living quarters, but does not include group quarters.

(3) *Separate living quarters* means living quarters:

(i) To which the occupants have access either:

(A) Directly from outside of the building, or

(B) Through a common hall that is accessible to other living quarters and that does not go through someone else's living quarters, and

(ii) Occupied by one or more persons who live and eat separately from occupant(s) of other living quarters, if any, in the same building.

Immersed heating element means an electrically powered heating device which is designed to operate while totally immersed in water in such a manner that the heat generated by the device is imparted directly to the water.

Import means to import into the customs territory of the United States.

Incandescent lamp means a lamp in which light is produced by a filament heated to incandescence by an electric current, including only the following:

(1) Any lamp (commonly referred to as lower wattage non-reflector general service lamps, including any tungsten halogen lamp) that has a rated wattage between 30 and 199, has an E26 medium screw base, has a rated voltage or voltage range that lies at least partially in the range of 115 and 130 volts, and is not a reflector lamp.

(2) Any incandescent reflector lamp.

(3) Any general service incandescent lamp (commonly referred to as a high- or higher-wattage lamp) that has a rated wattage above 199 (above 205 for a high wattage reflector lamp).

Incandescent reflector lamp (commonly referred to as a reflector lamp) means any lamp in which light is produced by a filament heated to incandescence by an electric current, which: is not colored or designed for rough or vibration service applications that contains an inner reflective coating on the outer bulb to direct the light; has an R, PAR, ER, BR, BPAR, or similar bulb shapes with an E26 medium screw base; has a rated voltage or voltage range that lies at least partially in the range of 115 and 130 volts; has a diameter that exceeds 2.25 inches; and has a rated wattage that is 40 watts or higher.

Indoor unit means a component of a split-system central air conditioner or heat pump that is designed to transfer heat between the refrigerant and the indoor air, and which consists of an indoor coil, a cooling mode expansion device, and may include an air moving device.

Intermediate base incandescent lamp means a lamp that uses an intermediate screw base as described in ANSI C81.61, Specifications for Electric Bases, common designation E17 (incorporated by reference; see §430.3).

Kerosene means No. 1 fuel oil with a viscosity meeting the specifications as specified in UL–730–1974, section 36.9 and in tables 2 and 3 of ANSI Standard Z91.1–1972.

Lamp Efficacy (LE) means the measured lumen output of a lamp in lumens divided by the measured lamp electrical power input in watts expressed in units of lumens per watt (LPW).

Light-emitting diode or *LED* means a p-n junction solid state device of which the radiated output, either in the infrared region, the visible region, or the ultraviolet region, is a function of the physical construction, material used, and exciting current of the device.

Low consumption has the meaning given such a term in ASME A112.19.2M–1995. (see §430.22)

Low pressure steam or hot water boiler means an electric, gas or oil burning furnace designed to supply low pressure steam or hot water for space heating application. A low pressure steam boiler operates at or below 15 pounds psig steam pressure; a hot water boiler operates at or below 160 psig water pressure and 250 °F. water temperature.

LP-gas means liquified petroleum gas, and includes propane, butane, and propane/butane mixtures.

Major cooking component means either a conventional cooking top, a conventional oven or a microwave oven.

Manufacture means to manufacture, produce, assemble, or import.

Manufacturer means any person who manufactures a consumer product.

Medium base compact fluorescent lamp means an integrally ballasted fluorescent lamp with a medium screw base, a rated input voltage range of 115 to 130 volts and which is designed as a direct replacement for a general service incandescent lamp; however, the term does not include—

(1) Any lamp that is—

(i) Specifically designed to be used for special purpose applications; and

(ii) Unlikely to be used in general purpose applications, such as the applications described in the definition of ''General Service Incandescent Lamp'' in this section; or

(2) Any lamp not described in the definition of ''General Service Incandescent Lamp'' in this section that is excluded by the Secretary, by rule, because the lamp is—

(i) Designed for special applications; and

(ii) Unlikely to be used in general purpose applications.

Medium screw base means an Edison screw base identified with the prefix E–26 in the ''American National Standard for Electric Lamp Bases'', ANSI_IEC C81.61–2003, published by the American National Standards Institute.

Microwave/conventional range means a class of kitchen ranges and ovens which is a household cooking appliance consisting of a microwave oven, a conventional oven, and a conventional cooking top.

Microwave oven means a class of kitchen ranges and ovens comprised of household cooking appliances consisting of a compartment designed to cook or heat food by means of microwave energy, including microwave ovens with or without thermal elements designed for surface browning of food and combination ovens.

Mobile home furnace means a direct vent furnace that is designed for use only in mobile homes.

Modified spectrum means, with respect to an incandescent lamp, an incandescent lamp that—

(1) Is not a colored incandescent lamp; and

(2) When operated at the rated voltage and wattage of the incandescent lamp—

(A) Has a color point with (x,y) chromaticity coordinates on the C.I.E. 1931 chromaticity diagram, figure 2, page 3 of IESNA LM–16 (incorporated by reference; *see* § 430.3) that lies below the black-body locus; and

(B) Has a color point with (x,y) chromaticity coordinates on the C.I.E. 1931 chromaticity diagram, figure 2, page 3 of IESNA LM–16 (incorporated by reference; *see* § 430.3) that lies at least 4 MacAdam steps, as referenced in IESNA LM–16, distant from the color point of a clear lamp with the same filament and bulb shape, operated at the same rated voltage and wattage.

Monochrome television set means an electrical device designed to convert incoming broadcast signals into monochrome television pictures and associated sound.

Natural gas means natural gas as defined by the Federal Power Commission.

Off mode means the condition in which an energy using product—

(1) Is connected to a main power source; and

(2) Is not providing any stand-by or active mode function.

Oil means heating oil grade No. 2 as defined in American Society for Testing and Materials (ASTM) D396–71.

Organic light-emitting diode or O*LED* means a thin-film light-emitting device that typically consists of a series of organic layers between 2 electrical contacts (electrodes).

Other clothes washer means a class of clothes washer which is not an automatic or semi-automatic clothes washer.

Other cooking products means any class of cooking products other than the conventional range, conventional cooking top, conventional oven, microwave oven, and microwave/conventional range classes.

Outdoor furnace or boiler is a furnace or boiler normally intended for installation out-of-doors or in an unheated space (such as an attic or a crawl space).

Outdoor unit means a component of a split-system central air conditioner or heat pump that is designed to transfer heat between the refrigerant and the outdoor air, and which consists of an outdoor coil, compressor(s), an air moving device, and in addition for heat pumps, a heating mode expansion device, reversing valve, and defrost controls.

Packaged terminal air conditioner means a wall sleeve and a separate unencased combination of heating and cooling assemblies specified by the builder and intended for mounting through the wall. It includes a prime source of refrigeration, separable outdoor louvers, forced ventilation, and heating availability energy.

Packaged terminal heat pump means a packaged terminal air conditioner that utilizes reverse cycle refrigeration as its prime heat source and should have supplementary heating availability by builder's choice of energy.

Person includes any individual, corporation, company, association, firm, partnership, society, trust, joint venture or joint stock company, the government, and any agency of the United States or any State or political subdivision thereof.

Pin-based means (1) the base of a fluorescent lamp, that is not integrally ballasted and that has a plug-in lamp base, including multi-tube, multibend, spiral, and circline types, or (2) a socket that holds such a lamp.

Pool heater means an appliance designed for heating nonpotable water contained at atmospheric pressure, including heating water in swimming pools, spas, hot tubs and similar applications.

Portable electric heater means an electric heater which is intended to stand unsupported, and can be moved from place to place within a structure. It is connected to electric supply by means of a cord and plug, and transfers heat by radiation and/or convention (either natural or forced).

Primary heater means a heating device that is the principal source of heat for a structure and includes baseboard electric heaters, ceiling electric heaters, and wall electric heaters.

Private labeler means an owner of a brand or trademark on the label of a consumer product which bears a private label. A consumer product bears a private label if:

(1) Such product (or its container) is labeled with the brand or trademark of a person other than a manufacturer of such product;

(2) The person with whose brand or trademark such product (or container) is labeled has authorized or caused such product to be so labeled; and

(3) The brand or trademark of a manufacturer of such product does not appear on such label.

Propane means a hydrocarbon whose chemical composition is predominantly C_3H_8, whether recovered from natural gas or crude oil.

R20 incandescent reflector lamp means a reflector lamp that has a face diameter of approximately 2.5 inches, as shown in figure 1(R) on page 7 of ANSI C79.1–1994 (incorporated by reference; *see* § 430.3).

Rated voltage with respect to incandescent lamps means:

(1) The design voltage if the design voltage is 115 V, 130 V or between 115V and 130 V:

(2) 115 V if the design voltage is less than 115 V and greater than or equal to 100 V and the lamp can operate at 115 V; and

(3) 130 V if the design voltage is greater than 130 V and less than or equal to 150 V and the lamp can operate at 130 V.

Rated wattage means:

(1) With respect to fluorescent lamps and general service fluorescent lamps:

(i) If the lamp is listed in ANSI C78.81 (incorporated by reference; *see* § 430.3) or ANSI C78.901 (incorporated by reference; *see* § 430.3), the rated wattage of a lamp determined by the lamp designation of Clause 11.1 of ANSI C78.81 or ANSI C78.901;

(ii) If the lamp is a residential straight-shaped lamp, and not listed in ANSI C78.81 (incorporated by reference; *see* § 430.3), the wattage of a lamp when operated on a reference ballast for which the lamp is designed; or

(iii) If the lamp is neither listed in one of the ANSI standards referenced in (1)(i) of this definition, nor a residential straight-shaped lamp, the electrical power of a lamp when measured according to the test procedures outlined in appendix R to subpart B of this part.

(2) With respect to general service incandescent lamps and incandescent reflector lamps, the electrical power measured according to the test procedures outlined in appendix R to subpart B of this part.

Refrigerator means an electric refrigerator.

Refrigerator-freezer means an electric refrigerator-freezer.

Replacement ballast means a ballast that—

(1) Is designed for use to replace an existing fluorescent lamp ballast in a previously installed luminaire;

(2) Is marked ''FOR REPLACEMENT USE ONLY'';

(3) Is shipped by the manufacturer in packages containing not more than 10 fluorescent lamp ballasts; and

(4) Has output leads that when fully extended are a total length that is less than the length of the lamp with which the ballast is intended to be operated.

Residential straight-shaped lamp means a low pressure mercury electric-discharge source in which a fluorescing coating transforms some of the ultraviolet energy generated by the mercury discharge into light, including a straight-shaped fluorescent lamp with medium bi-pin bases of nominal overall length of 48 inches and is either designed exclusively for residential applications; or designed primarily and marketed exclusively for residential applications.

(1) A lamp is designed exclusively for residential applications if it will not function for more than 100 hours with a commercial high-power-factor ballast.

(2) A lamp is designed primarily and marketed exclusively for residential applications if it:

(i) Is permanently and clearly marked as being for residential use only;

(ii) Has a life of 6,000 hours or less when used with a commercial high-power-factor ballast;

(iii) Is not labeled or represented as a replacement for a fluorescent lamp that is a covered product; and

(iv) Is marketed and distributed in a manner designed to minimize use of the lamp with commercial high-power-factor ballasts.

(3) A manufacturer may market and distribute a lamp in a manner designed to minimize use of the lamp with commercial high-power-factor ballasts by:

(i) Packaging and labeling the lamp in a manner that clearly indicates the lamp is for residential use only and includes appropriate instructions concerning proper and improper use; if the lamp is included in a catalog or price list that also includes commercial/industrial lamps, listing the lamp in a separate residential section accompanied by notes about proper use on the same page; and providing as part of any express warranty accompanying the lamp that improper use voids such warranty; or

(ii) Using other comparably effective measures to minimize use with commercial high-power-factor ballasts.

Room air conditioner means a consumer product, other than a ''packaged terminal air conditioner,'' which is powered by a single phase electric current and which is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilating and heating.

Rough or vibration service incandescent reflector lamp means a reflector lamp: in which a C–11 (5 support), C–17 (8 support), or C–22 (16 support) filament is mounted (the number of support excludes lead wires); in which the filament configuration is as shown in Chapter 6 of the 1993 *Illuminating Engineering Society of North America Lighting Handbook*, 8th Edition (see 10 CFR 430.22); and that is designated and marketed specifically for rough or vibration service applications.

Rough service lamp means a lamp that—

(1) Has a minimum of 5 supports with filament configurations that are C–7A, C–11, C–17, and C–22 as listed in Figure 6–12 of the IESNA Lighting Handbook (incorporated by reference; *see* § 430.3), or similar configurations where lead wires are not counted as supports; and

(2) Is designated and marketed specifically for 'rough service' applications, with

(i) The designation appearing on the lamp packaging; and

(ii) Marketing materials that identify the lamp as being for rough service.

Secretary means the Secretary of the Department of Energy.

Security or life safety alarm or surveillance system means:

(1) Equipment designed and marketed to perform any of the following functions (on a continuous basis):

(i) Monitor, detect, record, or provide notification of intrusion or access to real property or physical assets or notification of threats to life safety.

(ii) Deter or control access to real property or physical assets, or prevent the unauthorized removal of physical assets.

(iii) Monitor, detect, record, or provide notification of fire, gas, smoke, flooding, or other physical threats to real property, physical assets, or life safety.

(2) This term does not include any product with a principal function other than life safety, security, or surveillance that:

(i) Is designed and marketed with a built-in alarm or theft-deterrent feature; or

(ii) Does not operate necessarily and continuously in active mode.

Semi-automatic clothes washer means a class of clothes washer that is the same as an automatic clothes washer except that user intervention is required to regulate the water temperature by adjusting the external water faucet valves.

Shatter-resistant lamp, shatter-proof lamp, or *shatter-protected lamp* means a lamp that—

(1) Has a coating or equivalent technology that is compliant with NSF/ANSI 51 (incorporated by reference; *see* § 430.3) and is designed to contain the glass if the glass envelope of the lamp is broken; and

(2) Is designated and marketed for the intended application, with

(i) The designation on the lamp packaging; and

(ii) Marketing materials that identify the lamp as being shatter-resistant, shatter-proof, or shatter-protected.

Showerhead means any showerhead (including a hand held showerhead), except a safety shower showerhead.

Small duct, high velocity system means a heating and cooling product that contains a blower and indoor coil combination that:

(1) Is designed for, and produces, at least 1.2 inches of external static pressure when operated at the certified air volume rate of 220–350 CFM per rated ton of cooling; and

(2) When applied in the field, uses high velocity room outlets generally greater than 1000 fpm which have less than 6.0 square inches of free area.

Space constrained product means a central air conditioner or heat pump:

(1) That has rated cooling capacities no greater than 30,000 BTU/hr;

(2) That has an outdoor or indoor unit having at least two overall exterior dimensions or an overall displacement that:

(i) Is substantially smaller than those of other units that are:

(A) Currently usually installed in site-built single family homes; and

(B) Of a similar cooling, and, if a heat pump, heating capacity; and

(ii) If increased, would certainly result in a considerable increase in the usual cost of installation or would certainly result in a significant loss in the utility of the product to the consumer; and

(3) Of a product type that was available for purchase in the United States as of December 1, 2000.

Specialty application mercury vapor lamp ballast means a mercury vapor lamp ballast that—

(1) Is designed and marketed for operation of mercury vapor lamps used in quality inspection, industrial processing, or scientific use, including fluorescent microscopy and ultraviolet curing; and

(2) In the case of a specialty application mercury vapor lamp ballast, the label of which—

(i) Provides that the specialty application mercury vapor lamp ballast is 'For specialty applications only, not for general illumination'; and

(ii) Specifies the specific applications for which the ballast is designed.

Standby mode means the condition in which an energy-using product—

(1) Is connected to a main power source; and

(2) Offers one or more of the following user-oriented or protective functions:

(i) To facilitate the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer; or

(ii) Continuous functions, including information or status displays (including clocks) or sensor-based functions.

State means a State, the District of Columbia, Puerto Rico, or any territory or possession of the United States.

State regulation means a law or regulation of a State or political subdivision thereof.

Supplementary heater means a heating device that provides heat to a space in addition to that which is supplied by a primary heater. Supplementary heaters include portable electric heaters.

Surface unit means either a heating unit mounted in a cooking top, or a heating source and its associated heated area of the cooking top, on which vessels are placed for the cooking or heating of food.

Television set means a color television set or a monochrome television set.

Tested combination means a multi-split system with multiple indoor coils having the following features:

(1) The basic model of a system used as a tested combination shall consist of one outdoor unit, with one or more compressors, that is matched with between 2 and 5 indoor units; for multi-split systems, each of these indoor units shall be designed for individual operation.

(2) The indoor units shall—

(i) Represent the highest sales model family, or another indoor model family if the highest sales model family does not provide sufficient capacity (see ii);

(ii) Together, have a nominal capacity that is between 95% and 105% of the nominal capacity of the outdoor unit;

(iii) Not, individually, have a capacity that is greater than 50% of the nominal capacity of the outdoor unit;

(iv) Operate at fan speeds that are consistent with the manufacturer's specifications; and

(v) All be subject to the same minimum external static pressure requirement (i.e., 0 inches of water column for non-ducted, see Table 2 in appendix M to subpart B of this part for ducted indoor units) while being configurable to produce the same static pressure at the exit of each outlet plenum when manifolded as per section 2.4.1 of appendix M.

Through-the-wall air conditioner and heat pump means a central air conditioner or heat pump that is designed to be installed totally or partially within a fixed-size opening in an exterior wall, and:

(1) Is manufactured prior to January 23, 2010;

(2) Is not weatherized;

(3) Is clearly and permanently marked for installation only through an exterior wall;

(4) Has a rated cooling capacity no greater than 30,000 Btu/hr;

(5) Exchanges all of its outdoor air across a single surface of the equipment cabinet; and

(6) Has a combined outdoor air exchange area of less than 800 square inches (split systems) or less than 1,210 square inches (single packaged systems) as measured on the surface described in paragraph (5) of this definition.

Torchiere means a portable electric lamp with a reflector bowl that directs light upward to give indirect illumination.

Unvented gas heater means an unvented, self-contained, free-standing, nonrecessed gas-burning appliance which furnishes warm air by gravity or fan circulation.

Unvented home heating equipment means a class of home heating equipment, not including furnaces, used for the purpose of furnishing heat to a space proximate to such heater directly from the heater and without duct connections and includes electric heaters and unvented gas and oil heaters.

Unvented oil heater means an unvented, self-contained, free-standing, nonrecessed oil-burning appliance which furnishes warm air by gravity or fan circulation.

Urinal means a plumbing fixture which receives only liquid body waste and, on demand, conveys the waste through a trap seal into a gravity drainage system, except such term does not include fixtures designed for installations in prisons.

Vented floor furnace means a self-contained vented heater suspended from the floor of the space being heated, taking air for combustion from outside this space. The vented floor furnace supplies heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing.

Vented hearth heater means a vented appliance which simulates a solid fuel fireplace and is designed to furnish warm air, with or without duct connections, to the space in which it is installed. The circulation of heated room air may be by gravity or mechanical means. A vented hearth heater may be freestanding, recessed, zero clearance, or a gas fireplace insert or stove. The following products are not subject to the energy conservation standards for vented hearth heaters:

(1) Vented gas log sets and

(2) Vented gas hearth products that meet all of the following four criteria:

(i) Certified to ANSI Z21.50 (incorporated by reference; see § 430.3), but not to ANSI Z21.88 (incorporated by reference; see § 430.3);

(ii) Sold without a thermostat and with a warranty provision expressly voiding all manufacturer warranties in the event the product is used with a thermostat;

(iii) Expressly and conspicuously identified on its rating plate and in all manufacturer's advertising and product literature as a "Decorative Product: Not for use as a Heating Appliance"; and

(iv) With respect to products sold after January 1, 2015, not equipped with a standing pilot light or other continuously-burning ignition source.

Vented home heating equipment or *vented heater* means a class of home heating equipment, not including furnaces, designed to furnish warmed air to the living space of a residence, directly from the device, without duct connections (except that boots not to exceed 10 inches beyond the casing may be permitted and except for vented hearth heaters, which may be with or without duct connections) and includes: vented wall furnace, vented floor furnace, vented room heater, and vented hearth heater.

Vented room heater means a self-contained, free standing, nonrecessed, vented heater for furnishing warmed air to the space in which it is installed. The vented room heater supplies heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing.

Vented wall furnace means a self-contained vented heater complete with grilles or the equivalent, designed for incorporation in, or permanent attachment to, a wall of a residence and furnishing heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing.

Vibration service lamp means a lamp that—

(1) Has filament configurations that are C–5, C–7A, or C–9, as listed in Figure 6–12 of the IESNA Lighting Handbook (incorporated by reference; *see* §430.3) or similar configurations;

(2) Has a maximum wattage of 60 watts;

(3) Is sold at retail in packages of 2 lamps or less; and

(4) Is designated and marketed specifically for vibration service or vibration-resistant applications, with—

(i) The designation appearing on the lamp packaging; and

(ii) Marketing materials that identify the lamp as being vibration service only.

Voltage range means a band of operating voltages as marked on an incandescent lamp, indicating that the lamp is designed to operate at any voltage within the band.

Wall electric heater means an electric heater (excluding baseboard electric heaters) which is intended to be recessed in or surface mounted on walls, which transfers heat by radiation and/or convection (either natural or forced) and which includes forced convectors, natural convectors, radiant heaters, high wall or valance heaters.

Water closet means a plumbing fixture that has a water-containing receptor which receives liquid and solid body waste, and upon actuation, conveys the waste through an exposed integral trap seal into a gravity drainage system, except such term does not include fixtures designed for installation in prisons.

Water heater means a product which utilizes oil, gas, or electricity to heat potable water for use outside the heater upon demand, including—

(a) Storage type units which heat and store water at a thermostatically controlled temperature, including gas storage water heaters with an input of 75,000 Btu per hour or less, oil storage water heaters with an input of 105,000 Btu per hour or less, and electric storage water heaters with an input of 12 kilowatts or less;

(b) Instantaneous type units which heat water but contain no more than one gallon of water per 4,000 Btu per hour of input, including gas instantaneous water heaters with an input of 200,000 Btu per hour or less, oil instantaneous water heaters with an input of 210,000 Btu per hour or less, and electric instantaneous water heaters with an input of 12 kilowatts or less; and

(c) Heat pump type units, with a maximum current rating of 24 amperes at a voltage no greater than 250 volts, which are products designed to transfer thermal energy from one temperature level to a higher temperature level for the purpose of heating water, including all ancillary equipment such as fans, storage tanks, pumps, or controls necessary for the device to perform its function.

Water use means the quantity of water flowing through a showerhead, faucet, water closet, or urinal at point of use, determined in accordance with test procedures under appendices S and T of subpart B of this part.

Weatherized warm air furnace or boiler means a furnace or boiler designed for installation outdoors, approved for resistance to wind, rain, and snow, and supplied with its own venting system.

[42 FR 27898, June 1, 1977]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting §430.2, see the List of CFR Sections Affected, which appears in the Finding Aids section of the printed volume and at *www.fdsys.gov.*

EFFECTIVE DATE NOTE: At 76 FR 70628, Nov. 14, 2011, §430.2 was amended by adding the definition of "ballast luminous efficiency" in alphabetical order, effective Jan. 13, 2012.

For the convenience of the user, the added text is set forth as follows:

§ 430.2 Definitions.

* * * * *

Ballast luminous efficiency means the total fluorescent lamp arc power divided by the fluorescent lamp ballast input power multiplied by the appropriate frequency adjustment factor, as defined in appendix Q1 of subpart B of this part.

* * * * *

§ 430.3 Materials incorporated by reference.

(a) *General.* We incorporate by reference the following standards into part 430. The material listed has been approved for incorporation by reference by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Any subsequent amendment to a standard by the standard-setting organization will not affect the DOE regulations unless and until amended by DOE. Material is incorporated as it exists on the date of the approval and a notice of any change in the material will be published in the FEDERAL REGISTER. All approved material is available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to: *http://www.archives.gov/federal__register/code__of__federal__regulations/ibr__locations.html.* Also, this material is available for inspection at U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, 6th Floor, 950 L'Enfant Plaza, SW., Washington, DC 20024, (202) 586–2945, or go to: *http://www1.eere.energy.gov/buildings/appliance__standards/.* Standards can be obtained from the sources below.

(b) *AHRI.* Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd, Suite 500, Arlington, VA 22201, 703–524–8800, or go to *http://www.ahrinet.org.*

(1) ARI 210/240–2006, Unitary Air-Conditioning and Air-Source Heat Pump Equipment, approved March 26, 1998, IBR approved for appendix M to subpart B.

(2) [Reserved]

(c) *ANSI.* American National Standards Institute, 25 W. 43rd Street, 4th Floor, New York, NY 10036, 212–642–4900, or go to *http://www.ansi.org.*

(1) ANSI C78.3–1991 (''ANSI C78.3''), American National Standard for Fluorescent Lamps-Instant-start and Cold-Cathode Types-Dimensional and Electrical Characteristics, approved July 15, 1991; IBR approved for § 430.32.

(2) ANSI C78.20–2003, Revision of ANSI C78.20–1995 (''ANSI C78.20''), American National Standard for electric lamps—A, G, PS, and Similar Shapes with E26 Medium Screw Bases, approved October 30, 2003; IBR approved for § 430.2.

(3) ANSI C78.21–1989, American National Standard for Electric Lamps—PAR and R Shapes, approved March 3, 1989, IBR approved for § 430.2.

(4) ANSI C78.21–2003, Revision of ANSI C78.21–1995 with all supplements, American National Standard for Electric Lamps—PAR and R Shapes, approved October 30, 2003, IBR approved for § 430.2.

(5) ANSI__IEC C78.81–2005, Revision of ANSI C78.81–2003 (''ANSI C78.81''), American National Standard for Electric Lamps—Double-Capped Fluorescent Lamps—Dimensional and Electrical Characteristics, approved August 11, 2005; IBR approved for § 430.2, 430.32 and appendix R of subpart B.

(6) ANSI__IEC C78.81–2010 (''ANSI C78.81–2010''), American National Standard for Electric Lamps—Double-Capped Fluorescent Lamps—Dimensional and Electrical Characteristics, approved January 14, 2010; IBR approved for appendix Q and appendix Q1 to subpart B.

(7) ANSI C78.375–1997, Revision of ANSI C78.375–1991 (''ANSI C78.375''), American National Standard for Fluorescent Lamps—Guide for Electrical Measurements, first edition, approved September 25, 1997; IBR approved for appendix Q, appendix Q1 and appendix R to subpart B.

(8) ANSI__IEC C78.901–2005, Revision of ANSI C78.901–2001 (''ANSI C78.901''), American National Standard for Electric Lamps—Single-Based Fluorescent Lamps—Dimensional and Electrical Characteristics, approved March 23,

2005; IBR approved for § 430.2 and appendix R to subpart B.

(9) ANSI C79.1–1994, American National Standard for Nomenclature for Glass Bulbs—Intended for Use with Electric Lamps, approved March 24, 1994, IBR approved for § 430.2.

(10) ANSI C79.1–2002, American National Standard for Electric Lamps—Nomenclature for Glass Bulbs Intended for Use with Electric Lamps, approved September 16, 2002, IBR approved for § 430.2.

(11) ANSI_ANSLG_ C81.61–2006, Revision of ANSI C81.61–2005, (''ANSI C81.61''), American National Standard for electrical lamp bases—Specifications for Bases (Caps) for Electric Lamps, approved August 25, 2006, IBR approved for § 430.2.

(12) ANSI C82.1–2004, (''ANSI C82.1''), American National Standard for Lamp Ballast—Line Frequency Fluorescent Lamp Ballast, approved November 19, 2004; IBR approved for appendix Q and appendix Q1 to subpart B.

(13) ANSI C82.2–2002, (''ANSI C82.2''), American National Standard for Lamp Ballasts—Method of Measurement of Fluorescent Ballasts, Approved June 6, 2002, IBR approved for appendix Q and appendix Q1 to subpart B.

(14) ANSI C82.3–2002, Revision of ANSI C82.3–1983 (R 1995) (''ANSI C82.3''), American National Standard for Reference Ballasts for Fluorescent Lamps, approved September 4, 2002; IBR approved for appendix Q, appendix Q1 and appendix R to subpart B.

(15) ANSI C82.11 Consolidated-2002, (''ANSI C82.11''), American National Standard for Lamp Ballasts—High-frequency Fluorescent Lamp Ballasts—Supplements, approved March 11, 1999, August 5, 1999 and January 17, 2002; IBR approved for appendix Q and appendix Q1 to subpart B.

(16) ANSI C82.13–2002 (''ANSI C82.13''), American National Standard for Lamp Ballasts—Definitions for Fluorescent Lamps and Ballasts, approved July 23, 2002; IBR approved for appendix Q and appendix Q1 to subpart B.

(17) ANSI Z21.56–1994, Gas-Fired Pool Heaters, section 2.9, approved December 5, 1994, IBR approved for appendix P to subpart B.

(18) ANSI Z21.50–2007 (CSA 2.22–2007), (''ANSI Z21.50''), Vented Gas Fireplaces, Fifth Edition, Approved February 22, 2007, IBR approved for § 430.2.

(19) ANSI Z21.88–2009 (CSA 2.33–2009), (''ANSI Z21.88''), Vented Gas Fireplace Heaters, Fifth Edition, Approved March 26, 2009, IBR approved for § 430.2.

(d) [Reserved]

(e) *ASHRAE*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Publication Sales, 1791 Tullie Circle, NE., Atlanta, GA 30329, 800–527–4723 or 404–636–8400, or go to *http://www.ashrae.org*.

(1) ANSI/ASHRAE Standard 16–1983 (''ANSI/ASHRAE 16'') (RA 2009), (Reaffirmation of ANSI/ASHRAE Standard 16–1983 [RA 1999]), Method of Testing for Rating Room Air Conditioners and Packaged Terminal Air Conditioners, ASHRAE approved October 18, 1988, and reaffirmed June 20, 2009. ANSI approved October 20, 1998 and reaffirmed June 25, 2009. IBR approved for appendix F to subpart B.

(2) ASHRAE 23–2005, Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units, approved February 10, 2005, IBR approved for appendix M to subpart B.

(3) ASHRAE 37–2005, Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment, approved March 11, 2005, IBR approved for appendix M to subpart B.

(4) ASHRAE 41.1–1986 (Reaffirmed 2001), Standard Method for Temperature Measurement, approved February 18, 1987, IBR approved for appendix E and appendix M to subpart B.

(5) ASHRAE 41.2–1987 (Reaffirmed 1992), Standard Methods for Laboratory Airflow Measurement, approved October 1, 1987, IBR approved for appendix M to subpart B.

(6) ASHRAE 41.6–1994 (Reaffirmed 2001), Standard Method for Measurement of Moist Air Properties, approved August 30, 1994, IBR approved for appendix M to subpart B.

(7) ASHRAE 41.9–2000, Calorimeter Test Methods for Mass Flow Measurements of Volatile Refrigerants, approved October 6, 2000, IBR approved for appendix M to subpart B.

(8) ASHRAE/AMCA 51–1999/210–1999, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating,

approved December 2, 1999, IBR approved for appendix M to subpart B.

(9) ASHRAE 103–1993, Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers, (with Errata of October 24, 1996) except for sections 3.0, 7.2.2.5, 8.6.1.1, 9.1.2.2, 9.5.1.1, 9.5.1.2.1, 9.5.1.2.2, 9.5.2.1, 9.7.1, 10.0, 11.2.12, 11.3.12, 11.4.12, 11.5.12 and appendices B and C, approved October 4, 1993, IBR approved for § 430.23 and appendix N to subpart B.

(10) ASHRAE 116–1995 (RA 2005), Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps, approved July 24, 1995, IBR approved for appendix M to subpart B.

(f) *ASME*. American Society of Mechanical Engineers, Service Center, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007, 973–882–1170, or go to *http://www.asme.org*.

(1) ASME/ANSI A112.18.1M–1996, Plumbing Fixture Fittings, approved April 4, 1996, IBR approved for appendix S to subpart B.

(2) ASME/ANSI A112.19.6–1995, Hydraulic Requirements for Water Closets and Urinals, approved April 6, 1995, IBR approved for § 430.2 and appendix T to subpart B.

(g) *AHAM*. Association of Home Appliance Manufacturers, 1111 19th Street, NW., Suite 402, Washington, DC 20036, 202–872–5955, or go to *http://www.aham.org*.

(1) ANSI/AHAM DW–1–1992, American National Standard, Household Electric Dishwashers, approved February 6, 1992, IBR approved for appendix C to subpart B and § 430.32.

(2) AHAM HLD–1–2009 (''AHAM HLD–1''), Household Tumble Type Clothes Dryers, (2009), IBR approved for appendix D1 to subpart B.

(3) ANSI/AHAM HRF–1–1979, (Revision of ANSI B38.1–1970), (''HRF–1–1979''), *American National Standard, Household Refrigerators, Combination Refrigerator-Freezers and Household Freezers*, approved May 17, 1979, IBR approved for appendices A1 and B1 to subpart B.

(4) AHAM HRF–1–2008, (''HRF–1–2008''), Association of Home Appliance Manufacturers, Energy and Internal Volume of Refrigerating Appliances (2008), including Errata to Energy and Internal Volume of Refrigerating Appliances, Correction Sheet issued November 17, 2009, IBR approved for appendices A and B to subpart B.

(5) ANSI/AHAM RAC–1–2008 (''ANSI/AHAM RAC–1''), Room Air Conditioners, (2008; ANSI approved July 7, 2008), IBR approved for appendix F to subpart B.

(h) *CEC*. California Energy Commission, 1516 Ninth Street, MS–25, Sacramento, CA 95814, 916–654–4091, or go to *http://www.energy.ca.gov*.

(1) CEC Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc and Ac-Ac Power Supplies, August 11, 2004, IBR approved for appendix Z to subpart B.

(2) [Reserved]

(i) *CIE*. Commission Internationale de l'Eclairage (CIE), Central Bureau, Kegelgasse 27, A–1030, Vienna, Austria, 011+43 1 714 31 87 0, or go to *http://www.cie.co.at*.

(1) CIE 13.3–1995 (''CIE 13.3''), Technical Report: Method of Measuring and Specifying Colour Rendering Properties of Light Sources, 1995, ISBN 3 900 734 57 7; IBR approved for § 430.2 and appendix R to subpart B.

(2) CIE 15:2004 (''CIE 15''), Technical Report: Colorimetry, 3rd edition, 2004, ISBN 978 3 901906 33 6; IBR approved for appendix R to subpart B.

(j) *Environmental Protection Agency (EPA)*, ENERGY STAR documents published by the Environmental Protection Agency are available online at *http://www.energystar.gov* or by contacting the Energy Star hotline at 1–888–782–7937.

(1) ENERGY STAR Testing Facility Guidance Manual: Building a Testing Facility and Performing the Solid State Test Method for ENERGY STAR Qualified Ceiling Fans, Version 1.1, approved December 9, 2002, IBR approved for appendix U to subpart B.

(2) ENERGY STAR Program Requirements for Residential Light Fixtures, Version 4.0, approved January 10, 2005, IBR approved for appendix V to subpart B.

(3) ENERGY STAR Program Requirements for Dehumidifiers, approved January 1, 2001, IBR approved for appendix X to subpart B.

(4) Energy Star Program Requirements for Single Voltage External Ac-

Dc and Ac-Ac Power Supplies, Eligibility Criteria (Version 2.0), effective date for EPS Manufacturers November 1, 2008, IBR approved for subpart C, § 430.32.

(5) Test Methodology for Determining the Energy Performance of Battery Charging Systems, approved December 2005, IBR approved for appendix Y to subpart B.

(k) *IESNA*. Illuminating Engineering Society of North America, 120 Wall Street, Floor 17, New York, NY 10005–4001, 212–248–5000, or go to *http://www.iesna.org*.

(1) *The IESNA Lighting Handbook, Reference & Application*, (''The IESNA Lighting Handbook''), 9th ed., Chapter 6, ''Light Sources,'' July 2000, IBR approved for § 430.2.

(2) IESNA LM–9–99, (''LM–9''), IESNA Approved Method for the Electrical and Photometric Measurements of Fluorescent Lamps, 1999. IBR approved for § 430.2 and appendix R to subpart B.

(3) IESNA LM–16–1993 (''IESNA LM–16''), IESNA Practical Guide to Colorimetry of Light Sources, December 1993, IBR approved for § 430.2.

(4) IES LM–20–1994, IESNA Approved Method for Photometric Testing of Reflector-Type Lamps, approved December 3, 1994, IBR approved for appendix R to subpart B.

(5) IESNA LM–45–00, (''LM–45''), IESNA Approved Method for Electrical and Photometric Measurements of General Service Incandescent Filament Lamps, approved May 8, 2000; IBR approved for appendix R to subpart B.

(6) IES LM–58–1994, IESNA Guide to Spectroradiometric Measurements, approved December 3, 1994, IBR approved for appendix R to subpart B.

(l) *IEC*. International Electrotechnical Commission, available from the American National Standards Institute, 11 W. 42nd Street, New York, NY 10036, 212–642–4936 or go to *http://www.iec.ch*.

(1) International Electrotechnical Commission (IEC) Standard 62301 (''IEC 62301''), *Household electrical appliances—Measurement of standby power* (first edition, June 2005), IBR approved for appendix D1, appendix F, appendix I, and appendix N to subpart B.

(2) [Reserved]

(m) *NSF International*. NSF International, P.O. Box 130140, 789 North Dixboro Road, Ann Arbor, MI 48113–0140, 1–800–673–6275, or go to *http://www.nsf.org*.

(1) NSF/ANSI 51–2007 (''NSF/ANSI 51''), Food equipment materials, revised and adopted April 2007, IBR approved for § 430.2.

(2) [Reserved]

(n) *Optical Society of America. Optical Society of America*, 2010 Massachusetts Ave., NW., Washington, DC 20036–1012, 202–223–8130, or go to *http://www.opticsinfobase.org;*

(1) ''Computation of Correlated Color Temperature and Distribution Temperature,'' A.R. Robertson, Journal of the Optical Society of America, Volume 58, Number 11, November 1968, pages 1528–1535, IBR approved for § 430.2.

(2) [Reserved]

(o) *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy*, Resource Room of the Building Technologies Program, 950 L'Enfant Plaza, SW., 6th Floor, Washington, DC 20024, 202–586–2945, or go to *http://www.energystar.gov*.

(1) ENERGY STAR Program Requirements for [Compact Fluorescent Lamps] CFLs, Version 3.0, approved October 30, 2003, IBR approved for appendix V to subpart B.

(2) ENERGY STAR Program Requirements for [Compact Fluorescent Lamps] CFLs, approved August 9, 2001, IBR approved for appendix W to subpart B.

[74 FR 12066, Mar. 23, 2009, as amended at 74 FR 31840, July 6, 2009; 74 FR 34177, July 14, 2009; 74 FR 54455, Oct. 22, 2009; 75 FR 42583, July 22, 2010; 75 FR 64631, Oct. 20, 2010; 75 FR 78848, Dec. 16, 2010; 76 FR 1031, Jan. 6, 2011; 76 FR 12843, Mar. 9, 2011; 76 FR 25223, May 4, 2011; 76 FR 71859, Nov. 18, 2011]

§ 430.4 Sources for information and guidance.

(a) *General*. The standards listed in this paragraph are referred to in the DOE test procedures and elsewhere in this part but are not incorporated by reference. These sources are given here for information and guidance.

(b) *IESNA*. Illuminating Engineering Society of North America, 120 Wall Street, Floor 17, New York, NY 10005–4001, 212–248–5000, or go to *http://www.iesna.org*.

(1) *Illuminating Engineering Society of North America Lighting Handbook*, 8th Edition, 1993.

(2) [Reserved]

(c) *IEEE*. Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, 17th Floor, New York, NY, 10016–5997, 212–419–7900, or go to *http://www.ieee.org*.

(1) IEEE 1515–2000, IEEE Recommended Practice for Electronic Power Subsystems: Parameter Definitions, Test Conditions, and Test Methods, March 30, 2000.

(2) IEEE 100, Authoritative Dictionary of IEEE Standards Terms, 7th Edition, January 1, 2006.

(d) *IEC*. International Electrotechnical Commission, available from the American National Standards Institute, 11 W. 42nd Street, New York, NY 10036, 212–642–4936, or go to *http://www.iec.ch*.

(1) IEC 62301, Household electrical appliances—Measurement of standby power, First Edition, June 13, 2005.

(2) IEC 60050, International Electrotechnical Vocabulary.

(e) National Voluntary Laboratory Accreditation Program, Standards Services Division, NIST, 100 Bureau Drive, Stop 2140, Gaithersburg, MD 20899–2140, 301–975–4016, or go to *http://ts.nist.gov/standards/accreditation*.

(1) National Voluntary Laboratory Accreditation Program Handbook 150–01, Energy Efficient Lighting Products, Lamps and Luminaires, August 1993.

(2) [Reserved]

[74 FR 12066, Mar. 23, 2009]

Subpart B—Test Procedures

§ 430.21 Purpose and scope.

This subpart contains test procedures required to be prescribed by DOE pursuant to section 323 of the Act.

§ 430.23 Test procedures for the measurement of energy and water consumption.

When the test procedures of this section call for rounding off of test results, and the results fall equally between two values of the nearest dollar, kilowatt-hour, or other specified nearest value, the result shall be rounded up to the nearest higher value.

(a) *Refrigerators and refrigerator-freezers*. (1) The estimated annual operating cost for electric refrigerators and electric refrigerator-freezers without an anti-sweat heater switch shall be the product of the following three factors, the resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year;

(ii) The average per-cycle energy consumption for the standard cycle in kilowatt-hours per cycle, determined according to 6.2 (6.3.6 for externally vented units) of appendix A1 of this subpart before appendix A becomes mandatory and 6.2 (6.3.6 for externally vented units) of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(2) The estimated annual operating cost for electric refrigerators and electric refrigerator-freezers with an anti-sweat heater switch shall be the product of the following three factors, the resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year;

(ii) Half the sum of the average per-cycle energy consumption for the standard cycle and the average per-cycle energy consumption for a test cycle type with the anti-sweat heater switch in the position set at the factory just before shipping, each in kilowatt-hours per cycle, determined according to 6.2 (6.3.6 for externally vented units) of appendix A1 of this subpart before appendix A becomes mandatory and 6.2 (6.3.6 for externally vented units) of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(3) The estimated annual operating cost for any other specified cycle type for electric refrigerators and electric refrigerator-freezers shall be the product of the following three factors, the

resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year;

(ii) The average per-cycle energy consumption for the specified cycle type, determined according to 6.2 (6.3.6 for externally vented units) of appendix A1 to this subpart before appendix A becomes mandatory and 6.2 (6.3.6 for externally vented units) of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(4) The energy factor for electric refrigerators and electric refrigerator-freezers, expressed in cubic feet per kilowatt-hour per cycle, shall be:

(i) For electric refrigerators and electric refrigerator-freezers without an anti-sweat heater switch, the quotient of:

(A) The adjusted total volume in cubic feet, determined according to 6.1 of appendix A1 of this subpart before appendix A becomes mandatory and 6.1 of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A), divided by—

(B) The average per-cycle energy consumption for the standard cycle in kilowatt-hours per cycle, determined according to 6.2 (6.3.6 for externally vented units) of appendix A1 of this subpart before appendix A becomes mandatory and 6.2 (6.3.6 for externally vented units) of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A), the resulting quotient then being rounded off to the second decimal place; and

(ii) For electric refrigerators and electric refrigerator-freezers having an anti-sweat heater switch, the quotient of:

(A) The adjusted total volume in cubic feet, determined according to 6.1 of appendix A1 of this subpart before appendix A becomes mandatory and 6.1 of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A), divided by —

(B) Half the sum of the average per-cycle energy consumption for the standard cycle and the average per-cycle energy consumption for a test cycle type with the anti-sweat heater switch in the position set at the factory just before shipping, each in kilowatt-hours per cycle, determined according to 6.2 (6.3.6 for externally vented units) of appendix A1 of this subpart before appendix A becomes mandatory and 6.2 (6.3.6 for externally vented units) of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A), the resulting quotient then being rounded off to the second decimal place.

(5) The annual energy use of electric refrigerators and electric refrigerator-freezers, expressed in kilowatt-hours per year, shall be the following, rounded to the nearest kilowatt-hour per year:

(i) For electric refrigerators and electric refrigerator-freezers without an anti-sweat heater switch, the representative average use cycle of 365 cycles per year multiplied by the average per-cycle energy consumption for the standard cycle in kilowatt-hours per cycle, determined according to 6.2 (6.3.6 for externally vented units) of appendix A1 of this subpart before appendix A becomes mandatory and 6.2 (6.3.6 for externally vented units) of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A), and

(ii) For electric refrigerators and electric refrigerator-freezers having an anti-sweat heater switch, the representative average use cycle of 365 cycles per year multiplied by half the sum of the average per-cycle energy consumption for the standard cycle and the average per-cycle energy consumption for a test cycle type with the anti-sweat heater switch in the position set at the factory just before shipping, each in kilowatt-hours per cycle, determined according to 6.2 (6.3.6 for externally vented units) of appendix A1 of this subpart before appendix A becomes mandatory and 6.2 (6.3.6 for externally vented units) of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A).

(6) Other useful measures of energy consumption for electric refrigerators and electric refrigerator-freezers shall be those measures of energy consumption for electric refrigerators and electric refrigerator-freezers that the Secretary determines are likely to assist consumers in making purchasing decisions which are derived from the application of appendix A1 of this subpart before appendix A becomes mandatory appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A).

(7) The estimated regional annual operating cost for externally vented electric refrigerators and externally vented electric refrigerator-freezers without an anti-sweat heater switch shall be the product of the following three factors, the resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year,

(ii) The regional average per-cycle energy consumption for the standard cycle in kilowatt-hours per cycle, determined according to 6.3.7 of appendix A1 of this subpart before appendix A becomes mandatory and 6.3.7 of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(8) The estimated regional annual operating cost for externally vented electric refrigerators and externally vented electric refrigerator-freezers with an anti-sweat heater switch shall be the product of the following three factors, the resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year;

(ii) Half the sum of the average per-cycle energy consumption for the standard cycle and the regional average per-cycle energy consumption for a test cycle with the anti-sweat heater switch in the position set at the factory just before shipping, each in kilowatt-hours per cycle, determined according to 6.3.7 of appendix A1 of this subpart before appendix A becomes mandatory and 6.3.7 of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(9) The estimated regional annual operating cost for any other specified cycle for externally vented electric refrigerators and externally vented electric refrigerator-freezers shall be the product of the following three factors, the resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year;

(ii) The regional average per-cycle energy consumption for the specified cycle, in kilowatt-hours per cycle, determined according to 6.3.7 of appendix A1 of this subpart before appendix A becomes mandatory and 6.3.7 of appendix A of this subpart after appendix A becomes mandatory (see the note at the beginning of appendix A); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(10) The following principles of interpretation should be applied to the test procedure. The intent of the energy test procedure is to simulate typical room conditions (approximately 70 °F (21 °C)) with door openings, by testing at 90 °F (32.2 °C) without door openings. Except for operating characteristics that are affected by ambient temperature (for example, compressor percent run time), the unit, when tested under this test procedure, shall operate in a manner equivalent to the unit in typical room conditions. The energy used by the unit shall be calculated when a calculation is provided by the test procedure. Energy consuming components that operate in typical room conditions (including as a result of door openings, or a function of humidity), and that are not exempted by this test procedure, shall operate in an equivalent manner during energy testing under this test procedure, or be accounted for by all calculations as provided for in the test procedure. If:

(i) A product contains energy consuming components that operate differently during the prescribed testing than they would during representative average consumer use and

(ii) Applying the prescribed test to that product would evaluate it in a manner that is unrepresentative of its true energy consumption (thereby providing materially inaccurate comparative data), a manufacturer must obtain a waiver in accordance with the relevant provisions of 10 CFR part 430. Examples:

A. Energy saving features that are designed to be activated by a lack of door openings shall not be functional during the energy test.

B. The defrost heater should not either function or turn off differently during the energy test than it would when operating in typical room conditions.

C. Electric heaters that would normally operate at typical room conditions with door openings should also operate during the energy test.

D. Energy used during adaptive defrost shall continue to be tested and adjusted per the calculation provided for in this test procedure.

(b) *Freezers*. (1) The estimated annual operating cost for freezers without an anti-sweat heater switch shall be the product of the following three factors, the resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year;

(ii) The average per-cycle energy consumption for the standard cycle in kilowatt-hours per cycle, determined according to 6.2 of appendix B1 of this subpart before appendix B becomes mandatory and 6.2 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(2) The estimated annual operating cost for freezers with an anti-sweat heater switch shall be the product of the following three factors, the resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year;

(ii) Half the sum of the average per-cycle energy consumption for the standard cycle and the average per-cycle energy consumption for a test cycle type with the anti-sweat heater switch in the position set at the factory just before shipping, each in kilowatt-hours per cycle, determined according to 6.2 of appendix B1 of this subpart before appendix B becomes mandatory and 6.2 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(3) The estimated annual operating cost for any other specified cycle type for freezers shall be the product of the following three factors, the resulting product then being rounded off to the nearest dollar per year:

(i) The representative average-use cycle of 365 cycles per year;

(ii) The average per-cycle energy consumption for the specified cycle type, determined according to 6.2 of appendix B1 of this subpart before appendix B becomes mandatory and 6.2 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B); and

(iii) The representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary.

(4) The energy factor for freezers, expressed in cubic feet per kilowatt-hour per cycle, shall be:

(i) For freezers not having an anti-sweat heater switch, the quotient of:

(A) The adjusted net refrigerated volume in cubic feet, determined according to 6.1 of appendix B1 of this subpart before appendix B becomes mandatory and 6.1 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B), divided by—

(B) The average per-cycle energy consumption for the standard cycle in kilowatt-hours per cycle, determined according to 6.2 of appendix B1 of this subpart before appendix B becomes mandatory and 6.2 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B), the resulting quotient then being rounded off to the second decimal place; and

(ii) For freezers having an anti-sweat heater switch, the quotient of:

(A) The adjusted net refrigerated volume in cubic feet, determined according to 6.1 of appendix B1 of this subpart before appendix B becomes mandatory and 6.1 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B), divided by—

(B) Half the sum of the average per-cycle energy consumption for the standard cycle and the average per-cycle energy consumption for a test cycle type with the anti-sweat heater switch in the position set at the factory just before shipping, each in kilowatt-hours per cycle, determined according to 6.2 of appendix B1 of this subpart before appendix B becomes mandatory and 6.2 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B), the resulting quotient then being rounded off to the second decimal place.

(5) The annual energy use of all freezers, expressed in kilowatt-hours per year, shall be the following, rounded to the nearest kilowatt-hour per year:

(i) For freezers not having an anti-sweat heater switch, the representative average use cycle of 365 cycles per year multiplied by the average per-cycle energy consumption for the standard cycle in kilowatt-hours per cycle, determined according to 6.2 of appendix B1 of this subpart before appendix B becomes mandatory and 6.2 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B), and

(ii) For freezers having an anti-sweat heater switch, the representative average use cycle of 365 cycles per year multiplied by half the sum of the average per-cycle energy consumption for the standard cycle and the average per-cycle energy consumption for a test cycle type with the anti-sweat heater switch in the position set at the factory just before shipping, each in kilowatt-hours per cycle, determined according to 6.2 of appendix B1 of this subpart before appendix B becomes mandatory and 6.2 of appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B).

(6) Other useful measures of energy consumption for freezers shall be those measures the Secretary determines are likely to assist consumers in making purchasing decisions and are derived from the application of appendix B1 of this subpart before appendix B becomes mandatory and appendix B of this subpart after appendix B becomes mandatory (see the note at the beginning of appendix B).

(7) The following principles of interpretation should be applied to the test procedure. The intent of the energy test procedure is to simulate typical room conditions (approximately 70 °F (21 °C)) with door openings, by testing at 90 °F (32.2 °C) without door openings. Except for operating characteristics that are affected by ambient temperature (for example, compressor percent run time), the unit, when tested under this test procedure, shall operate in a manner equivalent to the unit in typical room conditions. The energy used by the unit shall be calculated when a calculation is provided by the test procedure. Energy consuming components that operate in typical room conditions (including as a result of door openings, or a function of humidity), and that are not exempted by this test procedure, shall operate in an equivalent manner during energy testing under this test procedure, or be accounted for by all calculations as provided for in the test procedure. If:

(i) A product contains energy consuming components that operate differently during the prescribed testing than they would during representative average consumer use and

(ii) Applying the prescribed test to that product would evaluate it in a manner that is unrepresentative of its true energy consumption (thereby providing materially inaccurate comparative data), a manufacturer must obtain a waiver in accordance with the relevant provisions of 10 CFR part 430. Examples:

A. Energy saving features that are designed to be activated by a lack of door openings hall not be functional during the energy test.

B. The defrost heater should not either function or turn off differently during the energy test than it would when in typical room conditions.

C. Electric heaters that would normally operate at typical room conditions with door openings should also operate during the energy test.

D. Energy used during adaptive defrost shall continue to be tested and adjusted per the calculation provided for in this test procedure.

(c) *Dishwashers.* (1) The Estimated Annual Operating Cost (EAOC) for dishwashers must be rounded to the nearest dollar per year and is defined as follows:

(i) When cold water (50 °F) is used,

(A) For dishwashers having a truncated normal cycle as defined in section 1.15 of appendix C to this subpart,

$$EAOC = (D_e \times S) + (D_e \times N \times (M - (E_D/2))).$$

(B) For dishwashers not having a truncated normal cycle,

$$EAOC = (D_e \times S) + (D_e \times N \times M)$$

Where,

D_e = the representative average unit cost of electrical energy, in dollars per kilowatt-hour, as provided by the Secretary,

S = the annual standby electrical energy in kilowatt-hours per year and determined according to section 5.6 of appendix C to this subpart,

N = the representative average dishwasher use of 215 cycles per year,

M = the machine electrical energy consumption per-cycle for the normal cycle as defined in section 1.6 of appendix C to this subpart, in kilowatt-hours and determined according to section 5.1 of appendix C to this subpart,

E_D = the drying energy consumption defined as energy consumed using the power-dry feature after the termination of the last rinse option of the normal cycle and determined according to section 5.2 of appendix C to this subpart.

(ii) When electrically-heated water (120 °F or 140 °F) is used,

(A) For dishwashers having a truncated normal cycle as defined in section 1.15 of appendix C to this subpart,

$$EAOC = (D_e \times S) + (D_e \times N \times (M - (E_D/2)))+ (D_e \times N \times W)$$

(B) For dishwashers not having a truncated normal cycle,

$$EAOC = (D_e \times S) + (D_e \times N \times M)+ (D_e \times N \times W)$$

Where,

D_e, S, N, M, and E_D, are defined in paragraph (c)(1)(i) of this section, and

W = the total water energy consumption per cycle for the normal cycle as defined in section 1.6 of appendix C to this subpart, in kilowatt-hours per cycle and determined according to section 5.4 of appendix C to this subpart.

(iii) When gas-heated or oil-heated water is used,

(A) For dishwashers having a truncated normal cycle as defined in section 1.15 of appendix C to this subpart,

$$EAOC_g = (D_e \times S) + (D_e \times N \times (M - (E_D/2)))+ (D_g \times N \times W_g)$$

(B) For dishwashers not having a truncated normal cycle,

(B) For dishwashers not having a truncated normal cycle,

$$EAOC_g = (D_e \times S) + (D_e \times N \times M)+ (D_g \times N \times W_g)$$

Where,

D_e, S, N, M, and E_D are defined in paragraph (c)(1)(i) of this section,

D_g = the representative average unit cost of gas or oil, as appropriate, in dollars per Btu, as provided by the Secretary, and

W_g = the total water energy consumption per cycle for the normal cycle as defined in section 1.6 of appendix C to this subpart, in Btu's per cycle and determined according to section 5.5 of appendix C to this subpart.

(2) The energy factor for dishwashers, EF, expressed in cycles per kilowatt-hour is defined as follows:

(i) When cold water (50 °F) is used,

(A) For dishwashers having a truncated normal cycle as defined in section 1.15 of appendix C to this subpart,

$$EF = 1/(M - (E_D/2))$$

(B) For dishwashers not having a truncated normal cycle,

$$EF = 1/M$$

Where,

M, and E_D are defined in paragraph (c)(1)(i) of this section.

(ii) When electrically-heated water (120 °F or 140 °F) is used,

(A) For dishwashers having a truncated normal cycle as defined in section 1.15 of appendix C to this subpart,

$$EF = 1/(M - (E_D/2)+W)$$

(B) For dishwashers not having a truncated normal cycle,

$$EF = 1/(M+W)$$

Where,

M, and E_D are defined in paragraph (c)(1)(i) of this section, and W is defined in paragraph (c)(1)(ii)of this section.

(3) The estimated annual energy use, EAEU, expressed in kilowatt-hours per year is defined as follows:

(i) For dishwashers having a truncated normal cycle as defined in section 1.15 of appendix C to this subpart,

$$EAEU = (M - (E_D/2)+W) \times N+S$$

Where,

M, E_D, N and S are defined in paragraph (c)(1)(i) of this section, and W is defined in paragraph (c)(1)(ii) of this section.

(ii) For dishwashers not having a truncated normal cycle,

$$EAEU = (M+W) \times N+S$$

Where,

M, N and S are defined in paragraph (c)(1)(i) of this section, and W is defined in paragraph (c)(1)(ii) of this section.

(4) Other useful measures of energy consumption for dishwashers are those which the Secretary determines are likely to assist consumers in making purchasing decisions and which are derived from the application of appendix C to this subpart.

(d) *Clothes dryers.* (1) The estimated annual operating cost for clothes dryers shall be—

(i) For an electric clothes dryer, the product of the following three factors:

(A) The representative average-use cycle of 283 cycles per year,

(B) The per-cycle combined total energy consumption in kilowatt-hours per-cycle, determined according to 4.6 of appendix D1 to this subpart, and

(C) The representative average unit cost of electrical energy in dollars per kilowatt-hour as provided by the Secretary, the resulting product then being rounded off to the nearest dollar per year, and

(ii) For a gas clothes dryer, the product of the representative average-use cycle of 283 cycles per year times the sum of:

(A) The product of the per-cycle gas dryer electric energy consumption in kilowatt-hours per cycle, determined according to 4.2 of appendix D1 to this subpart, times the representative average unit cost of electrical energy in dollars per kilowatt-hour as provided by the Secretary plus,

(B) The product of the per-cycle gas dryer gas energy consumption, in Btus per cycle, determined according to 4.3 of appendix D1 to this subpart, times the representative average unit cost for natural gas or propane, as appropriate, in dollars per Btu as provided by the Secretary, the resulting product then being rounded off to the nearest dollar per year plus,

(C) The product of the per-cycle standby mode and off mode energy consumption in kilowatt-hours per cycle, determined according to 4.5 of appendix D1 to this subpart, times the representative average unit cost of electrical energy in dollars per kilowatt-hour as provided by the Secretary.

(2) The energy factor, expressed in pounds of clothes per kilowatt-hour, for clothes dryers shall be either the quotient of a 3-pound bone-dry test load for compact dryers, as defined by 2.7.1 of appendix D to this subpart before the date that appendix D1 becomes mandatory, or the quotient of a 7-pound bone-dry test load for standard dryers, as defined by 2.7.2 of appendix D to this subpart before the date that appendix D1 becomes mandatory, as applicable, divided by the clothes dryer energy consumption per cycle, as determined according to 4.1 for electric clothes dryers and 4.6 for gas clothes dryers of appendix D to this subpart before the date that appendix D1 becomes mandatory, the resulting quotient then being rounded off to the nearest hundredth (.01). Upon the date that appendix D1 to this subpart becomes mandatory, the energy factor is determined in accordance with 4.7 of appendix D1, the result then being rounded off to the nearest hundredth (.01).

(3) Upon the date that appendix D1 to this subpart becomes mandatory, the combined energy factor is determined in accordance with 4.8 of appendix D1, the result then being rounded off to the nearest hundredth (.01).

(4) Other useful measures of energy consumption for clothes dryers shall be those measures of energy consumption for clothes dryers which the Secretary determines are likely to assist consumers in making purchasing decisions

and which are derived from the application of appendix D to this subpart before the date that appendix D1 becomes mandatory and appendix D1 upon the date that appendix D1 to this subpart becomes mandatory.

(e) *Water Heaters*. (1) The estimated annual operating cost for water heaters shall be—

(i) For a gas or oil water heater, the product of the annual energy consumption, determined according to section 6.1.8 or 6.2.5 of appendix E of this subpart, times the representative average unit cost of gas or oil, as appropriate, in dollars per Btu as provided by the Secretary, the resulting product then being rounded off to the nearest dollar per year.

(ii) For an electric water heater, the product of the annual energy consumption, determined according to section 6.1.8 or 6.2.5 of appendix E of this subpart, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary, divided by 3412 Btu per kilowatt-hour, the resulting quotient then being rounded off to the nearest dollar per year.

(2) The energy factor for the water heaters shall be—

(i) For a gas or oil water heater, as determined by section 6.1.7 or 6.2.4 of appendix E of this subpart rounded off to the nearest 0.01.

(ii) For an electric water heater, as determined by section 6.1.7 or 6.2.4 of appendix E of this subpart rounded off to the nearest 0.01.

(3) Other useful measures of energy consumption for water heaters shall be those measures of energy consumption for water heaters which the Secretary determines are likely to assist consumers in making purchasing decisions and which are derived from the application of appendix E of this subpart.

(4) The alternative uniform test method for measuring the energy consumption of untested water heaters shall be that set forth in section 7.0 of appendix E of this subpart.

(f) *Room air conditioners*. (1) The estimated annual operating cost for room air conditioners, expressed in dollars per year, shall be determined by multiplying the following three factors:

(i) The combined annual energy consumption for room air conditioners, expressed in kilowatt-hours per year, as determined in accordance with paragraph (f)(4) of this section, and

(ii) A representative average unit cost of electrical energy in dollars per kilowatt-hour as provided by the Secretary, the resulting product then being rounded off to the nearest dollar per year.

(2) The energy efficiency ratio for room air conditioners, expressed in Btus per watt-hour, shall be the quotient of:

(i) The cooling capacity in Btus per hour as determined in accordance with 5.1 of appendix F to this subpart divided by:

(ii) The electrical input power in watts as determined in accordance with 5.2 of appendix F to this subpart, the resulting quotient then being rounded off to the nearest 0.1 Btu per watt-hour.

(3) The average annual energy consumption for room air conditioners, expressed in kilowatt-hours per year, shall be determined by multiplying together the following two factors:

(i) Electrical input power in kilowatts as determined in accordance with 5.2 of appendix F to this subpart, and

(ii) The representative average-use cycle of 750 hours of compressor operation per year, the resulting product then being rounded off to the nearest kilowatt-hour per year.

(4) The combined annual energy consumption for room air conditioners, expressed in kilowatt-hours per year, shall be the sum of:

(i) The average annual energy consumption as determined in accordance with paragraph (f)(4) of this section, and

(ii) The standby mode and off mode energy consumption, as determined in accordance with 5.3 of appendix F to this subpart, the resulting sum then being rounded off to the nearest kilowatt-hour per year.

(5) The combined energy efficiency ratio for room air conditioners, expressed in Btu's per watt-hour, shall be the quotient of:

(i) The cooling capacity in Btus per hour as determined in accordance with

5.1 of appendix F to this subpart multiplied by the representative average-use cycle of 750 hours of compressor operation per year, divided by

(ii) The combined annual energy consumption as determined in accordance with paragraph (f)(4) of this section multiplied by a conversion factor of 1,000 to convert kilowatt-hours to watt-hours, the resulting quotient then being rounded off to the nearest 0.1 Btu per watt-hour.

(g) *Unvented home heating equipment.* (1) The estimated annual operating cost for primary electric heaters, shall be the product of: (i) The average annual electric energy consumption in kilowatt-hours per year, determined according to section 3.1 of appendix G of this subpart and (ii) the representative average unit cost in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting product then being rounded off to the nearest dollar per year.

(2) The estimated regional annual operating cost for primary electric heaters, shall be the product of: (i) The regional annual electric energy consumption in kilowatt-hours per year for primary heaters determined according to section 3.2 of appendix G of this subpart and (ii) the representative average unit cost in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting product then being rounded off to the nearest dollar per year.

(3) The estimated operating cost per million Btu output shall be—

(i) For primary and supplementary electric heaters and unvented gas and oil heaters without an auxiliary electric system, the product of: (A) One million; and (B) the representative unit cost in dollars per Btu for natural gas, propane, or oil, as provided pursuant to section 323(b)(2) of the Act as appropriate, or the quotient of the representative unit cost in dollars per kilowatt-hour, as provided pursuant to section 323(b)(2) of the Act, divided by 3,412 Btu per kilowatt hour, the resulting product then being rounded off to the nearest 0.01 dollar per million Btu output; and

(ii) For unvented gas and oil heaters with an auxiliary electric system, the product of: (A) The quotient of one million divided by the rated output in Btu's per hour as determined in 3.4 of appendix G of this subpart; and (B) the sum of: (*1*) The product of the maximum fuel input in Btu's per hour as determined in 2.2. of this appendix times the representative unit cost in dollars per Btu for natural gas, propane, or oil, as appropriate, as provided pursuant to section 323(b)(2) of the Act, plus (*2*) the product of the maximum auxiliary electric power in kilowatts as determined in 2.1 of appendix G of this subpart times the representative unit cost in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting quantity shall be rounded off to the nearest 0.01 dollar per million Btu output.

(4) The rated output for unvented heaters is the rated output as determined according to either sections 3.3 or 3.4 of appendix G of this subpart, as appropriate, with the result being rounded to the nearest 100 Btu per hour.

(5) Other useful measures of energy consumption for unvented home heating equipment shall be those measures of energy consumption for unvented home heating equipment which the Secretary determines are likely to assist consumers in making purchasing decisions and which are derived from the application of appendix G of this subpart.

(h) [Reserved]

(i) *Kitchen ranges and ovens.* (1) The estimated annual operating cost for conventional ranges, conventional cooking tops, and conventional ovens shall be the sum of the following products: (i) The total annual electrical energy consumption for any electrical energy usage, in kilowatt-hours (kWh's) per year, times the representative average unit cost for electricity, in dollars per kWh, as provided pursuant to section 323(b)(2) of the Act; plus (ii) the total annual gas energy consumption for any natural gas usage, in British thermal units (Btu's) per year, times the representative average unit cost for natural gas, in dollars per Btu, as provided pursuant to section 323(b)(2) of the Act; plus (iii) the total annual gas energy consumption for any propane usage, in Btu's per year, times the representative average unit cost for propane, in dollars per Btu, as provided pursuant to section 323(b)(2) of the Act. The total annual energy consumption for conventional ranges, conventional cooking tops, and conventional ovens shall be as determined according to 4.3, 4.2.2, and 4.1.2, respectively, of appendix I to this subpart. The estimated annual operating cost shall be rounded off to the nearest dollar per year.

(2) The cooking efficiency for conventional cooking tops and conventional ovens shall be the ratio of the cooking energy output for the test to the cooking energy input for the test, as determined according to 4.2.1 and 4.1.3, respectively, of appendix I to this subpart. The final cooking efficiency values shall be rounded off to three significant digits.

(3) [Reserved]

(4) The energy factor for conventional ranges, conventional cooking tops, and conventional ovens shall be the ratio of the annual useful cooking energy output to the total annual energy input, as determined according to 4.3, 4.2.3, 4.1.4, respectively, of appendix I to this subpart. The final energy factor values shall be rounded off to three significant digits.

(5) There shall be two estimated annual operating costs, two cooking efficiencies, and two energy factors for convertible cooking appliances—(i) an estimated annual operating cost, a cooking efficiency and an energy factor which represent values for those three measures of energy consumption for the operation of the appliance with natural gas; and (ii) an estimated annual operating cost, a cooking efficiency and an energy factor which represent values for those three measures of energy consumption for the operation of the appliance with LP-gas.

(6) The estimated annual operating cost for convertible cooking appliances which represents natural gas usage, as described in paragraph (i)(5)(i) of this section, shall be determined according to paragraph (i)(1) of this section using the total annual gas energy consumption for natural gas times the representative average unit cost for natural gas.

(7) The estimated annual operating cost for convertible cooking appliances which represents LP-gas usage, as described in paragraph (i)(5)(ii) of this section, shall be determined according to paragraph (i)(1) of this section using the representative average unit cost for propane times the total annual energy consumption of the test gas, either propane or natural gas.

(8) The cooking efficiency for convertible cooking appliances which represents natural gas usage, as described in paragraph (i)(5)(i) of this section, shall be determined according to paragraph (i)(2) of this section when the appliance is tested with natural gas.

(9) The cooking efficiency for convertible cooking appliances which represents LP-gas usage, as described in paragraph (i)(5)(ii) of this section, shall be determined according to paragraph (i)(2) of this section, when the appliance is tested with either natural gas or propane.

(10) The energy factor for convertible cooking appliances which represents natural gas usage, as described in paragraph (i)(5)(i) of this section, shall be determined according to paragraph (i)(4) of this section when the appliance is tested with natural gas.

(11) The energy factor for convertible cooking appliances which represents LP-gas usage, as described in paragraph (i)(5)(ii) of this section, shall be determined according to paragraph (i)(4) of this section when the appliance is tested with either natural gas or propane.

(12) Other useful measures of energy consumption for conventional ranges, conventional cooking tops, and conventional ovens shall be those measures of energy consumption which the Secretary determines are likely to assist consumers in making purchasing decisions and which are derived from the application of appendix I to this subpart.

(13) The energy test procedure is designed to provide a measurement representative of average consumer use of the product, even if the test conditions and procedures may not be identical to average consumer use (*for example*, specified display times). If a product contains energy consuming components that operate differently during the prescribed testing than they would during representative average consumer use, and applying the prescribed

test to that product would evaluate it in a manner that is unrepresentative of its true energy consumption (thereby providing materially inaccurate comparative data), the prescribed procedure may not be used. For example, the energy use of a component in a product (*such as* display wattage) may not vary predictably as a function of operating conditions or control inputs—such as when a display is automatically dimmed when test conditions or test settings are reached. A manufacturer wishing to test such a product must obtain a waiver in accordance with the relevant provisions of 10 CFR part 430.

(j) *Clothes washers.* (1) The estimated annual operating cost for automatic and semi-automatic clothes washers shall be—

(i) When electrically heated water is used, the product of the following three factors:

(A) The representative average-use of 392 cycles per year,

(B) The total per-cycle energy consumption in kilowatt-hours per cycle determined according to 4.1.6 of appendix J before appendix J1 becomes mandatory and 4.1.7 of appendix J1 when appendix J1 becomes mandatory, (see the note at the beginning of appendix J1), and

(C) The representative average unit cost in dollars per kilowatt-hour as provided by the Secretary, the resulting product then being rounded off to the nearest dollar per year, and

(ii) When gas-heated or oil-heated water is used, the product of: the representative average-use of 392 cycles per year and the sum of both:

(A) The product of the per-cycle machine electrical energy consumption in kilowatt-hours per cycle, determined according to 4.1.5 of appendix J before the date that appendix J1 to the subpart becomes mandatory or 4.1.6 of appendix J1 upon the date that appendix J1 to this subpart becomes mandatory, and the representative average unit cost in dollars per kilowatt-hours as provided by the Secretary, and

(B) The product of the per-cycle water energy consumption for gas-heated or oil-heated water in BTU per cycle, determined according to 4.1.4 of appendix J before the date that appendix J1 becomes mandatory or 4.1.4 of appendix J1 upon the date that appendix J1 to this subpart becomes mandatory, and the representative average unit cost in dollars per Btu for oil or gas, as appropriate, as provided by the Secretary, the resulting product then being rounded off to the nearest dollar per year.

(2)(i) The energy factor for automatic and semi-automatic clothes washers is determined in accordance with 4.5 of appendix J before the date that appendix J1 becomes mandatory or 4.5 of appendix J1 upon the date that appendix J1 to this subpart becomes mandatory. The result shall be rounded off to the nearest 0.01 cubic foot per kilowatt-hours.

(ii) The modified energy factor for automatic and semi-automatic clothes washers is determined in accordance with 4.4 of appendix J before the date that appendix J1 becomes mandatory or 4.4 of appendix J1 upon the date that appendix J1 to this subpart becomes mandatory. The result shall be rounded off to the nearest 0.01 cubic foot per kilowatt-hours.

(3) Other useful measures of energy consumption for automatic or semi-automatic clothes washers shall be those measures of energy consumption which the Secretary determines are likely to assist consumers in making purchasing decisions and which are derived from the application of appendix J before the date that appendix J1 becomes mandatory or appendix J1 upon the date that appendix J1 to this subpart becomes mandatory. In addition, the annual water consumption of a clothes washer can be determined by the product of:

(A) The representative average-use of 392 cycles per year, and

(B) The total weighted per-cycle water consumption in gallons per cycle determined according to 4.3.2 of appendix J before the date that appendix J1 becomes mandatory or 4.2.2 of appendix J1 upon the date that appendix J1 to this subpart becomes mandatory. The water consumption factor can be determined in accordance with 4.3.3 of appendix J before the date that appendix J1 becomes mandatory or 4.2.3 of appendix J1 upon the date that appendix J1 to this subpart becomes mandatory. The remaining moisture content can be determined in accordance with 3.3 of appendix J before the date that appendix J1 becomes mandatory or 3.8 of appendix J1 upon the date that appendix J1 to this subpart becomes mandatory.

(k)–(l) [Reserved]

(m) *Central Air Conditioners and heat pumps.* (1) The estimated annual operating cost for cooling-only units and air-source heat pumps shall be one of the following:

(i) For cooling-only units or the cooling portion of the estimated annual operating cost for air-source heat pumps which provide both heating and cooling, the product of:

(A) The quotient of the cooling capacity, in Btu's per hour, determined from the steady-state wet-coil test (A or A_2 Test), as described in section 3.2 of appendix M to this subpart, divided by the seasonal energy efficiency ratio (SEER), in Btu's per watt-hour, determined from section 4.1 of appendix M to this subpart;

(B) The representative average use cycle for cooling of 1,000 hours per year;

(C) A conversion factor of 0.001 kilowatt per watt; and

(D) The representative average unit cost of electricity in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting product then being rounded off to the nearest dollar per year.

(ii) For air-source heat pumps which provide only heating or the heating portion of the estimated annual operating cost for air-source heat pumps which provide both heating and cooling, the product of:

(A) The quotient of the standardized design heating requirement, in Btu's per hour, nearest to the heating Region IV minimum design heating requirement, determined in section 4.2 of appendix M to this subpart, divided by the heating seasonal performance factor (HSPF), in Btu's per watt-hour, calculated for heating Region IV corresponding to the above-mentioned standardized design heating requirement and determined in section 4.2 of appendix M to this subpart;

(B) The representative average use cycle for heating of 2,080 hours per year;

(C) The adjustment factor of 0.77 which serves to adjust the calculated design heating requirement and heating load hours to the actual load experienced by a heating system;

(D) A conversion factor of 0.001 kilowatt per watt; and

(E) The representative average unit cost of electricity in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting product then being rounded off to the nearest dollar per year.

(iii) For air-source heat pumps which provide both heating and cooling, the estimated annual operating cost is the sum of the quantity determined in paragraph (m)(1)(i) of this section added to the quantity determined in paragraph (m)(1)(ii) of this section.

(2) The estimated regional annual operating cost for cooling-only units and for air-source heat pumps shall be one of the following:

(i) For cooling-only units or the cooling portion of the estimated regional annual operating cost for air-source heat pumps which provide both heating and cooling, the product of:

(A) The quotient of the cooling capacity, in Btu's per hour, determined from the steady-state wet-coil test (A or A_2 Test), as described in section 3.2 of appendix M to this subpart, divided by the seasonal energy efficiency ratio (SEER), in Btu's per watt-hour, determined from section 4.1 of appendix M to this subpart;

(B) The estimated number of regional cooling load hours per year determined from Figure 3 in section 4.3 of appendix M to this subpart;

(C) A conversion factor of 0.001 kilowatts per watt; and

(D) The representative average unit cost of electricity in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting product then being rounded off to the nearest dollar per year.

(ii) For air-source heat pumps which provide only heating or the heating portion of the estimated regional annual operating cost for air-source heat pumps which provide both heating and cooling, the product of:

(A) The estimated number of regional heating load hours per year determined from Figure 2 in section 4.3 of appendix M to this subpart;

(B) The quotient of the standardized design heating requirement, in Btu's per hour, for the appropriate generalized climatic region of interest (*i.e.*, corresponding to the regional heating load hours from ''A'') and determined in section 4.2 of appendix M to this subpart, divided by the heating seasonal performance factor (HSPF), in Btu's per watt-hour, calculated for the appropriate generalized climatic region of interest and corresponding to the above-mentioned standardized design heating requirement while being determined in section 4.2 of appendix M to this subpart;

(C) The adjustment factor of 0.77 which serves to adjust the calculated design heating requirement and heating load hours to the actual load experienced by a heating system;

(D) A conversion factor of 0.001 kilowatts per watt; and

(E) The representative average unit cost of electricity in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting product then being rounded off to the nearest dollar per year.

(iii) For air-source heat pumps which provide both heating and cooling, the estimated regional annual operating cost is the sum of the quantity determined in paragraph (m)(3)(i) of this section added to the quantity determined in paragraph (m)(3)(ii) of this section.

(3) The measure(s) of efficiency of performance for cooling-only units and air-source heat pumps shall be one or more of the following:

(i) The cooling mode efficiency measure for cooling-only units and air-source heat pumps which provide cooling shall be the seasonal energy efficiency ratio (SEER), in Btu's per watt-hour, determined according to section 4.1 of appendix M to this subpart, rounded off to the nearest 0.05.

(ii) The heating mode efficiency measure for air-source heat pumps shall be the heating seasonal performance factors (HSPF), in Btu's per watt-hour, determined according to section 4.2 of appendix M to this subpart for each applicable standardized design heating requirement within each climatic region, rounded off to the nearest 0.05.

(iii) The annual efficiency measure for air-source heat pumps which provide heating and cooling, shall be the annual performance factors (APF), in Btu's per watt-hour, determined according to section 4.3 of appendix M to this subpart for each standardized design heating requirement within each climatic region, rounded off to the nearest 0.05.

(4) The average off mode power consumption for central air conditioners and central air conditioning heat pumps shall be determined according to appendix M of this subpart. Round the average off mode power consumption to the nearest watt.

(5) Other useful measures of energy consumption for central air conditioners shall be those measures of energy consumption which the Secretary of Energy determines are likely to assist consumers in making purchasing decisions and which are derived from the application of appendix M to this subpart.

(6) All measures of energy consumption must be determined by the test method as set forth in appendix M to this subpart; or by an alternative rating method set forth in § 430.24(m)(4) as approved by the Assistant Secretary for Energy Efficiency and Renewable Energy in accordance with § 430.24(m)(5).

(n) *Furnaces*. (1) The estimated annual operating cost for furnaces is the sum of: (i) The product of the average annual fuel energy consumption, in Btu's per year for gas or oil furnaces or in kilowatt-hours per year for electric furnaces, determined according to section 10.2.2 or 10.3 of appendix N of this subpart, respectively, and the representative average unit cost in dollars per Btu for gas or oil, or dollars per kilowatt-hour for electric, as appropriate, as provided pursuant to section 323(b)(2) of the Act, plus (ii) the product of the average annual auxiliary electric energy consumption in kilowatt-hours per year determined according to section 10.2.3 of appendix N of this subpart, and the representative average unit cost in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting sum then being rounded off to the nearest dollar per year. (For furnaces which operate with variable inputs, an estimated annual operating cost is to be calculated for each degree of oversizing specified in section 10 of appendix N of this subpart.)

(2) The annual fuel utilization efficiency for furnaces, expressed in percent, is the ratio of the annual fuel output of useful energy delivered to the heated space to the annual fuel energy input to the furnace determined according to section 10.1 of appendix N of this subpart for gas and oil furnaces and determined in accordance with section 11.1 of the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ANSI/ASHRAE) Standard 103–1993 (incorporated by reference, see § 430.3) for electric furnaces. Round the annual fuel utilization efficiency to the nearest whole percentage point.

(3) The estimated regional annual operating cost for furnaces is the sum of: (i) The product of the regional annual fuel energy consumption in Btu's per year for gas or oil furnaces or in kilowatt-hours per year for electric furnaces, determined according to section 10.5.1 or 10.5.3 of appendix N of this subpart, respectively, and the representative average unit cost in dollars per Btu for gas or oil, or dollars per kilowatt-hour for electric, as appropriate, as provided pursuant to section 323(b)(2) of the Act, plus (ii) the product of the regional annual auxiliary electrical energy consumption in kilowatt-hours per year, determined according to section 10.5.2 of appendix N of this subpart, and the representative average unit cost in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting sum then being rounded off to the nearest dollar per year.

(4) The energy factor for furnaces, expressed in percent, is the ratio of annual fuel output of useful energy delivered to the heated space to the total annual energy input to the furnace determined according to section 10.4 of appendix N of this subpart.

(5) The average standby mode and off mode electrical power consumption for furnaces shall be determined according to section 8.6 of appendix N of this subpart. Round the average standby mode and off mode electrical power consumption to the nearest watt.

(6) Other useful measures of energy consumption for furnaces shall be those measures of energy consumption which the Secretary determines are likely to assist consumers in making purchasing decisions and which are derived from the application of appendix N of this subpart.

(o) *Vented home heating equipment.* (1) The annual fuel utilization efficiency for vented home heating equipment, expressed in percent, which is the ratio of the annual fuel output of useful energy delivered to the heated space to the annual fuel energy input to the vented heater, shall be determined either according to section 4.1.17 of appendix O of this subpart for vented heaters without either manual controls or thermal stack dampers; according to section 4.2.6 of appendix O of this subpart for vented heaters equipped with manual controls; or according to section 4.3.7 of appendix O of this subpart for vented heaters equipped with thermal stack dampers.

(2) The estimated annual operating cost for vented home heating equipment is the sum of: (i) The product of the average annual fuel energy consumption, in Btu's per year for natural gas, propane, or oil fueled vented home heating equipment, determined according to section 4.6.2 of appendix O of this subpart, and the representative average unit cost in dollars per Btu for natural gas, propane, or oil, as appropriate, as provided pursuant to section 323(b)(2) of the Act; plus (ii) The product of the average annual auxiliary electric energy consumption in kilowatt-hours per year determined according to section 4.6.3 of appendix O of this subpart, and the representative average unit cost in dollars per kilowatt-hours as provided pursuant to section 323(b)(2) of the Act, the resulting sum then being rounded off to the nearest dollar per year.

(3) The estimated operating cost per million Btu output for gas or oil vented home heating equipment with an auxiliary electric system shall be the product of: (A) The quotient of one million

Btu divided by the sum of: (*1*) The product of the maximum fuel input in Btu's per hour as determined in 3.1.1 or 3.1.2 of appendix 0 of this subpart times the annual fuel utilization efficiency in percent as determined in 4.1.17, 4.2.6, or 4.3.7 of this appendix as appropriate divided by 100, plus (*2*) the product of the maximum electric power in watts as determined in 3.1.3 of appendix 0 of this subpart times the quantity 3.412; and (B) of the sum of: (*1*) the product of the maximum fuel input in Btu's per hour as determined in 3.1.1 of this appendix times the representative unit cost in dollars per Btu for natural gas, propane, or oil, as appropriate, as provided pursuant to section 323(b)(2) of the Act; plus (*2*) the product of the maximum auxiliary electric power in kilowatts as determined in 3.1.3 of appendix O of this subpart times the representative unit cost in dollars per kilowatt-hour as provided pursuant to section 323(b)(2) of the Act, the resulting quantity shall be rounded off to the nearest 0.01 dollar per million Btu output.

(4) Other useful measures of energy consumption for vented home heating equipment shall be those measures of energy consumption which the Secretary determines are likely to assist consumers in making purchasing decisions and which are derived from the application of appendix O of this subpart.

(p) *Pool heaters.* (1) The estimated annual operating cost for pool heaters is the sum of:

(i) The product of the average annual fuel energy consumption, in Btu's per year, of natural gas or oil fueled pool heaters, determined according to section 4.2 of appendix P of this subpart, and the representative average unit cost in dollars per Btu for natural gas or oil, as appropriate, as provided pursuant to section 323(b)(2) of the Act; plus

(ii) The product of the average annual auxiliary electric energy consumption in kilowatt-hours per year determined according to section 4.3 of appendix P of this subpart, and the representative average unit cost in dollars per kilowatt-hours as provided pursuant to section 323(b)(2) of the Act, the resulting sum then being rounded off to the nearest dollar per year.

(2) The thermal efficiency of pool heaters, expressed as a percent, shall be determined in accordance with section 4 of appendix P to this subpart.

(q) *Fluorescent Lamp Ballasts.* (1) The Estimated Annual Energy Consumption (EAEC) for fluorescent lamp ballasts, expressed in kilowatt-hours per year, shall be the product of:

(i) The input power in kilowatts as determined in accordance with section 3.1.3.1 of appendix Q to this subpart; and

(ii) The representative average use cycle of 1,000 hours per year, the resulting product then being rounded off to the nearest kilowatt-hour per year.

(2) Ballast Efficacy Factor (BEF) shall be as determined in section 4.2 of appendix Q of this subpart.

(3) The Estimated Annual Operating Cost (EAOC) for fluorescent lamp ballasts, expressed in dollars per year, shall be the product of:

(i) The representative average unit energy cost of electricity in dollars per kilowatt-hour as provided by the Secretary,

(ii) The representative average use cycle of 1,000 hours per year, and

(iii) The input power in kilowatts as determined in accordance with section 3.1.3.1 of appendix Q to this subpart, the resulting product then being rounded off to the nearest dollar per year.

(4) Standby power consumption of certain fluorescent lamp ballasts shall be measured in accordance with section 3.2 of appendix Q to this subpart.

(r) *General service fluorescent lamps, general service incandescent lamps, and incandescent reflector lamps.* (1) The estimated annual energy consumption for general service fluorescent lamps, general service incandescent lamps, and incandescent reflector lamps, expressed in kilowatt-hours per year, shall be the product of the input power in kilowatts as determined in accordance with section 4 of appendix R to this subpart and an average annual use specified by the manufacturer, with the resulting product rounded off to the nearest kilowatt-hour per year. Manufacturers must provide a clear and accurate description of the assumptions used for the estimated annual energy consumption.

(2) The lamp efficacy for general service fluorescent lamps shall be equal to the average lumen output divided by the average lamp wattage as determined in section 4 of appendix R of this subpart, with the resulting quotient rounded off to the nearest tenth of a lumen per watt.

(3) The lamp efficacy for general service incandescent lamps shall be equal to the average lumen output divided by the average lamp wattage as determined in section 4 of appendix R of this subpart, with the resulting quotient rounded off to the nearest tenth of a lumen per watt.

(4) The lamp efficacy for incandescent reflector lamps shall be equal to the average lumen output divided by the average lamp wattage as determined in section 4 of appendix R of this subpart, with the resulting quotient rounded off to the nearest tenth of a lumen per watt.

(5) The color rendering index of a general service fluorescent lamp shall be tested and determined in accordance with section 4.4 of appendix R of this subpart and rounded off to the nearest unit.

(s) *Faucets.* The maximum permissible water use allowed for lavatory faucets, lavatory replacement aerators, kitchen faucets, and kitchen replacement aerators, expressed in gallons and liters per minute (gpm and L/min), shall be measured in accordance to section 2(a) of appendix S of this subpart. The maximum permissible water use allowed for metering faucets, expressed in gallons and liters per cycle (gal/cycle and L/cycle), shall be measured in accordance to section 2(a) of appendix S of this subpart.

(t) *Showerheads.* The maximum permissible water use allowed for showerheads, expressed in gallons and liters per minute (gpm and L/min), shall be measured in accordance to section 2(b) of appendix S of this subpart.

(u) *Water closets.* The maximum permissible water use allowed for water closets, expressed in gallons and liters per flush (gpf and Lpf), shall be measured in accordance to section 3(a) of appendix T of this subpart.

(v) *Urinals.* The maximum permissible water use allowed for urinals, expressed in gallons and liters per flush (gpf and Lpf), shall be measured in accordance to section 3(b) of appendix T of this subpart.

(w) *Ceiling fans.* The airflow and airflow efficiency for ceiling fans, expressed in cubic feet per minute (CFM) and CFM per watt (CFM/watt), respectively, shall be measured in accordance with section 4 of appendix U of this subpart.

(x) *Ceiling fan light kits.* The efficacy, expressed in lumens per watt (lumens/watt), for ceiling fan light kits with sockets for medium screw base lamps or pin-based fluorescent lamps shall be measured in accordance with section 4 of appendix V of this subpart.

(y) *Medium Base Compact Fluorescent Lamps.* The initial efficacy, lumen maintenance at 1,000 hours, lumen maintenance at 40-percent of rated life, rapid cycle stress test, and lamp life shall be measured in accordance with section 4 of appendix W of this subpart.

(z) *Dehumidifiers.* The energy factor for dehumidifiers, expressed in liters per kilowatt hour (L/kWh), shall be measured in accordance with section 4 of appendix X of this subpart.

(aa) *Battery Chargers.* Upon the effective date of any energy conservation standard for battery chargers governing active and maintenance mode energy consumption, the 24-hour energy consumption of a battery charger in active and maintenance modes, expressed in watt-hours, and the power consumption of a battery charger in maintenance mode, expressed in watts, shall be measured in accordance with section 5.10 of appendix Y of this subpart. The power consumption of a battery charger in standby mode and off mode, expressed in watts, shall be measured in accordance with sections 5.11 and 5.12, respectively, of appendix Y of this subpart.

(bb) *External Power Supplies.* The energy consumption of an external power supply, including active-mode efficiency expressed as a percentage and the no-load, off, and standby mode energy consumption levels expressed in watts, shall be measured in accordance with section 4 of appendix Z of this subpart.

[42 FR 27898, June 1, 1977]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting § 430.23, see the List of CFR

Sections Affected, which appears in the Finding Aids section of the printed volume and at *www.fdsys.gov*.

§ 430.24 [Reserved]

§ 430.25 Laboratory Accreditation Program.

Testing for fluorescent lamp ballasts performed in accordance with appendix Q1 to this subpart shall comply with this section § 430.25. The testing for general service fluorescent lamps, general service incandescent lamps, and incandescent reflector lamps shall be performed in accordance with appendix R to this subpart. The testing for medium base compact fluorescent lamps shall be performed in accordance with appendix W of this subpart. This testing shall be conducted by test laboratories accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) or by an accrediting organization recognized by NVLAP. NVLAP is a program of the National Institute of Standards and Technology, U.S. Department of Commerce. NVLAP standards for accreditation of laboratories that test for compliance with standards for fluorescent lamp ballast luminous efficiency (BLE), lamp efficacy, and CRI are set forth in 15 CFR part 285. A manufacturer's or importer's own laboratory, if accredited, may conduct the applicable testing. Testing for BLE may also be conducted by laboratories accredited by Underwriters Laboratories or Council of Canada. Testing for fluorescent lamp ballasts performed in accordance with appendix Q to this subpart is not required to be conducted by test laboratories accredited by NVLAP or an accrediting organization recognized by NVLAP.

[76 FR 25223, May 4, 2011]

§ 430.27 Petitions for waiver and applications for interim waiver.

(a)(1) Any interested person may submit a petition to waive for a particular basic model any requirements of § 430.23, or of any appendix to this subpart, upon the grounds that the basic model contains one or more design characteristics which either prevent testing of the basic model according to the prescribed test procedures, or the prescribed test procedures may evaluate the basic model in a manner so unrepresentative of its true energy consumption characteristics, or water consumption characteristics (in the case of faucets, showerheads, water closets, and urinals) as to provide materially inaccurate comparative data.

(2) Any interested person who has submitted a Petition for Waiver as provided in this subpart may also file an Application for Interim Waiver of the applicable test procedure requirements.

(b)(1) A Petition for Waiver shall be submitted either electronically to *AS_Waiver_Requests@ee.doe.gov* or by mail, in triplicate, to U.S. Department of Energy, Building Technologies Program, Test Procedure Waiver, 1000 Independence Avenue, SW., Mailstop EE–2J, Washington, DC 20585–0121. Each Petition for Waiver shall:

(2) An Application for Interim Waiver shall be submitted in triplicate, with the required three copies of the Petition for Waiver, to the Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy. Each Application for Interim Waiver shall reference the Petition for Waiver by identifying the particular basic model(s) for which a waiver and temporary exception are being sought. Each Application for Interim Waiver shall demonstrate likely success of the Petition for Waiver and shall address what economic hardship and/or competitive disadvantage is likely to result absent a favorable determination on the Application for Interim Waiver. Each Application for Interim Waiver shall be signed by the applicant or by an authorized representative.

(c)(1) Each petitioner, after filing a Petition for Waiver with DOE, and after the Petition for Waiver has been published in the FEDERAL REGISTER, shall, within five working days of such publication, notify in writing all known manufacturers of domestically marketed units of the same product type (as listed in section 322(a) of the Act) and shall include in the notice a statement that DOE has published in the FEDERAL REGISTER on a certain date the Petition for Waiver and supporting documents from which confidential information, if any, as determined by DOE, has been deleted in accordance with 10 CFR 1004.11. Each petitioner, in complying with the requirements of this paragraph, shall file with DOE a statement certifying the names and addresses of each person to whom a notice of the Petition for Waiver has been sent.

(2) Each applicant for Interim Waiver, whether filing jointly with, or subsequent to, a Petition for Waiver with DOE, shall concurrently notify in writing all known manufacturers of domestically marketed units of the same product type (as listed in Section 322(a) of the Act) and shall include in the notice a copy of the Petition for Waiver and a copy of the Application for Interim Waiver. In complying with this section, each applicant shall in the written notification include a statement that the Assistant Secretary for Conservation and Renewable Energy will receive and consider timely written comments on the Application for Interim Waiver. Each applicant, upon filing an Application for Interim Waiver, shall in complying with the requirements of this paragraph certify to DOE that a copy of these documents have been sent to all known manufacturers of domestically marked units of the same product type (as listed in section 322(a) of the Act). Such certification shall include the names and addresses of such persons. Each applicant also shall comply with the provisions of paragraph (c)(1) of this section with respect to the petition for waiver.

(d) Any person submitting written comments to DOE with respect to an Application for Interim Waiver shall also send a copy of the comments to the applicant.

(e) If administratively feasible, applicant shall be notified in writing of the disposition of the Application for Interim Waiver within 15 business days of receipt of the application. Notice of DOE's determination on the Application for Interim Waiver shall be published in the FEDERAL REGISTER.

(f) The filing of an Application for Interim Waiver shall not constitute grounds for noncompliance with any requirements of this subpart, until an Interim Waiver has been granted.

(g) An Interim Waiver from test procedure requirements will be granted by the Assistant Secretary for Conservation and Renewable Energy if it is determined that the applicant will experience economic hardship if the Application for Interim Waiver is denied, if it appears likely that the Petition for Waiver will be granted, and/or the Assistant Secretary determines that it would be desirable for public policy reasons to grant immediate relief pending a determination on the Petition for Waiver.

(h) An interim waiver will terminate 180 days after issuance or upon the determination on the Petition for Waiver, whichever occurs first. An interim waiver may be extended by DOE for 180 days. Notice of such extension and/or any modification of the terms or duration of the interim waiver shall be published in the FEDERAL REGISTER, and shall be based on relevant information contained in the record and any comments received subsequent to issuance of the interim waiver.

(i) Following publication of the Petition for Waiver in the FEDERAL REGISTER, a petitioner may, within 10 working days of receipt of a copy of any comments submitted in accordance with paragraph (b)(1) of this section, submit a rebuttal statement to the Assistant Secretary for Conservation and Renewable Energy. A petitioner may rebut more than one response in a single rebuttal statement.

(j) The petitioner shall be notified in writing as soon as practicable of the disposition of each Petition for Waiver. The Assistant Secretary for Conservation and Renewable Energy shall issue a decision on the petition as soon as is practicable following receipt and review of the Petition for Waiver and other applicable documents, including, but not limited to, comments and rebuttal statements.

(k) The filing of a Petition for Waiver shall not constitute grounds for noncompliance with any requirements of this subpart, until a waiver or interim waiver has been granted.

(l) Waivers will be granted by the Assistant Secretary for Conservation and Renewable Energy, if it is determined that the basic model for which the waiver was requested contains a design characteristic which either prevents testing of the basic model according to the prescribed test procedures, or the prescribed test procedures may evaluate the basic model in a manner so unrepresentative of its true energy consumption characteristics, or water consumption characteristics (in the case of faucets, showerheads, water closets, and urinals) as to provide materially inaccurate comparative data. Waivers may be granted subject to conditions, which may include adherence to alternate test procedures specified by the Assistant Secretary for Conservation and Renewable Energy. The Assistant Secretary shall consult with the Federal Trade Commission prior to granting any waiver, and shall promptly publish in the FEDERAL REGISTER notice of each waiver granted or denied, and any limiting conditions of each waiver granted.

(m) Within one year of the granting of any waiver, the Department of Energy will publish in the FEDERAL REGISTER a notice of proposed rulemaking to amend its regulations so as to eliminate any need for the continuation of such waiver. As soon thereafter as practicable, the Department of Energy will publish in the FEDERAL REGISTER a final rule. Such waiver will terminate on the effective date of such final rule.

(n) In order to exhaust administrative remedies, any person aggrieved by an action under this section must file an appeal with the DOE's Office of Hearings and Appeals as provided in 10 CFR part 1003, subpart C.

[51 FR 42826, Nov. 26, 1986, as amended at 60 FR 15017, Mar. 21, 1995; 63 FR 13316, Mar. 18, 1998; 76 FR 12502, Mar. 7, 2011]

APPENDIX A TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF ELECTRIC REFRIGERATORS AND ELECTRIC REFRIGERATOR-FREEZERS

The provisions of appendix A shall apply to all products manufactured on or after the effective date of any amended standards promulgated by DOE pursuant to Section 325(b)(4) of the Energy Policy and Conservation Act of 1975, as amended by the Energy Independence and Security Act of 2007 (to be codified at 42 U.S.C. 6295(b)(4)).

1. Definitions

Section 3, *Definitions*, of HRF–1–2008 (incorporated by reference; see §430.3) applies to this test procedure.

1.1 ''Adjusted total volume'' means the sum of:

(i) The fresh food compartment volume as defined in HRF–1–2008 (incorporated by reference; see §430.3) in cubic feet, and

(ii) The product of an adjustment factor and the net freezer compartment volume as defined in HRF–1–2008 in cubic feet.

1.2 ''All-refrigerator'' means an electric refrigerator that does not include a compartment for the freezing and long time storage of food at temperatures below 32 °F (0.0 °C). It may include a compartment of 0.50 cubic-foot capacity (14.2 liters) or less for the freezing and storage of ice.

1.3 ''Anti-sweat heater'' means a device incorporated into the design of a refrigerator or refrigerator-freezer to prevent the accumulation of moisture on the exterior or interior surfaces of the cabinet.

1.4 ''Anti-sweat heater switch'' means a user-controllable switch or user interface which modifies the activation or control of anti-sweat heaters.

1.5 ''Automatic defrost'' means a system in which the defrost cycle is automatically initiated and terminated, with resumption of normal refrigeration at the conclusion of the defrost operation. The system automatically prevents the permanent formation of frost on all refrigerated surfaces. Nominal refrigerated food temperatures are maintained during the operation of the automatic defrost system.

1.6 ''Automatic icemaker'' means a device, that can be supplied with water without user intervention, either from a pressurized water supply system or by transfer from a water reservoir located inside the cabinet, that automatically produces, harvests, and stores ice in a storage bin, with means to automatically interrupt the harvesting operation when the ice storage bin is filled to a pre-determined level.

1.7 ''Cycle'' means the period of 24 hours for which the energy use of an electric refrigerator or electric refrigerator-freezer is calculated as though the consumer activated compartment temperature controls were set to maintain the standardized temperatures (see section 3.2).

1.8 ''Cycle type'' means the set of test conditions having the calculated effect of operating an electric refrigerator or electric refrigerator-freezer for a period of 24 hours, with the consumer activated controls other than those that control compartment temperatures set to establish various operating characteristics.

1.9 ''Defrost cycle type'' means a distinct sequence of control whose function is to remove frost and/or ice from a refrigerated surface. There may be variations in the defrost control sequence such as the number of defrost heaters energized. Each such variation establishes a separate distinct defrost cycle type. However, defrost achieved regularly during the compressor off-cycles by warming of the evaporator without active heat addition is not a defrost cycle type.

1.10 ''Externally vented refrigerator or refrigerator-freezer'' means an electric refrigerator or electric refrigerator-freezer that has an enclosed condenser or an enclosed condenser/compressor compartment and a set of air ducts for transferring the exterior air from outside the building envelope into, through, and out of the refrigerator or refrigerator-freezer cabinet; is capable of mixing exterior air with the room air before discharging into, through, and out of the condenser or condenser/compressor compartment; may include thermostatically controlled dampers or controls that mix the exterior and room air at low outdoor temperatures and exclude exterior air when the outdoor air temperature is above 80 °F (26.7 °C) or the room air temperature; and may have a thermostatically actuated exterior air fan.

1.11 ''HRF–1–2008'' means AHAM Standard HRF–1–2008, Association of Home Appliance Manufacturers, Energy and Internal Volume of Refrigerating Appliances (2008), including Errata to Energy and Internal Volume of Refrigerating Appliances, Correction Sheet issued November 17, 2009. Only sections of HRF–1–2008 (incorporated by reference; see §430.3) specifically referenced in this test procedure are part of this test procedure. In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over HRF–1–2008.

1.12 ''Long-time automatic defrost'' means an automatic defrost system whose successive defrost cycles are separated by 14 hours or more of compressor operating time.

1.13 ''Separate auxiliary compartment'' means a freezer compartment or a fresh food compartment of a refrigerator or refrigerator-freezer having more than two compartments that is not the first freezer compartment or the first fresh food compartment. Access to a separate auxiliary compartment is through a separate exterior door or doors rather than through the door or doors of another compartment. Separate auxiliary compartments may be convertible (e.g., from fresh food to freezer). Separate auxiliary freezer compartments may not be larger than the first freezer compartment and separate auxiliary fresh food compartments may not be larger than the first fresh food compartment, but such size restrictions do not apply to separate auxiliary convertible compartments.

1.14 ''Special compartment'' means any compartment other than a butter conditioner, without doors directly accessible from the exterior, and with separate temperature control (such as crispers convertible to meat keepers) that is not convertible from fresh food temperature range to freezer temperature range.

1.15 ''Stabilization period'' means the total period of time during which steady-state conditions are being attained or evaluated.

1.16 ''Standard cycle'' means the cycle type in which the anti-sweat heater control, when provided, is set in the highest energy-consuming position.

1.17 ''Variable anti-sweat heater control'' means an anti-sweat heater control that varies the average power input of the anti-sweat heater(s) based on operating condition variable(s) and/or ambient condition variable(s).

1.18 ''Variable defrost control'' means an automatic defrost system in which successive defrost cycles are determined by an operating condition variable or variables other than solely compressor operating time. This includes any electrical or mechanical device performing this function. A control scheme that changes the defrost interval from a fixed length to an extended length (without any intermediate steps) is not considered a variable defrost control. A variable defrost control feature should predict the accumulation of frost on the evaporator and react accordingly. Therefore, the times between defrost should vary with different usage patterns and include a continuum of lengths of time between defrosts as inputs vary.

2. Test Conditions

2.1 Ambient Temperature. The ambient temperature shall be 90.0 ± 1 °F (32.2 ± 0.6 °C) during the stabilization period and the test period.

2.2 Operational Conditions. The electric refrigerator or electric refrigerator-freezer shall be installed and its operating conditions maintained in accordance with HRF–1–2008, (incorporated by reference; see §430.3), section 5.3 through section 5.5.5.5 (excluding section 5.5.5.4). Exceptions and clarifications to the cited sections of HRF–1–2008 are noted in sections 2.3 through 2.8, and 5.1 of this test procedure.

2.3 Anti-Sweat Heaters. The anti-sweat heater switch is to be on during one test and off during a second test. In the case of an electric refrigerator-freezer equipped with variable anti-sweat heater control, the standard cycle energy use shall be the result of the calculation described in 6.2.3.

2.4 Conditions for Automatic Defrost Refrigerator-Freezers. For automatic defrost refrigerator-freezers, the freezer compartments shall not be loaded with any frozen food packages during testing. Cylindrical metallic masses of dimensions 1.12 ± 0.25

inches (2.9 ± 0.6 cm) in diameter and height shall be attached in good thermal contact with each temperature sensor within the refrigerated compartments. All temperature measuring sensor masses shall be supported by low-thermal-conductivity supports in such a manner to ensure that there will be at least 1 inch (2.5 cm) of air space separating the thermal mass from contact with any interior surface or hardware inside the cabinet. In case of interference with hardware at the sensor locations specified in section 5.1, the sensors shall be placed at the nearest adjacent location such that there will be a 1-inch air space separating the sensor mass from the hardware.

2.5 Conditions for All-Refrigerators. There shall be no load in the freezer compartment during the test.

2.6 The cabinet and its refrigerating mechanism shall be assembled and set up in accordance with the printed consumer instructions supplied with the cabinet. Set-up of the refrigerator or refrigerator-freezer shall not deviate from these instructions, unless explicitly required or allowed by this test procedure. Specific required or allowed deviations from such set-up include the following:

(a) Connection of water lines and installation of water filters are not required;

(b) Clearance requirements from surfaces of the product shall be as described in section 2.8 of this appendix;

(c) The electric power supply shall be as described in HRF–1–2008 (incorporated by reference; see §430.3), section 5.5.1;

(d) Temperature control settings for testing shall be as described in section 3 below. Settings for convertible compartments and other temperature-controllable or special compartments shall be as described in section 2.7 of this appendix;

(e) The product does not need to be anchored or otherwise secured to prevent tipping during energy testing;

(f) All the product's chutes and throats required for the delivery of ice shall be free of packing, covers, or other blockages that may be fitted for shipping or when the icemaker is not in use; and

(g) Ice storage bins shall be emptied of ice.

For cases in which set-up is not clearly defined by this test procedure, manufacturers must submit a petition for a waiver (see section 7).

2.7 Compartments that are convertible (e.g., from fresh food to freezer) shall be operated in the highest energy use position. For the special case of convertible separate auxiliary compartments, this means that the compartment shall be treated as a freezer compartment or a fresh food compartment, depending on which of these represents higher energy use. Special compartments shall be tested with controls set to provide the coldest temperature. However, for special compartments in which temperature control is achieved using the addition of heat (including resistive electric heating, refrigeration system waste heat, or heat from any other source, but excluding the transfer of air from another part of the interior of the product) for any part of the controllable temperature range of that compartment, the product energy use shall be determined by averaging two sets of tests. The first set of tests shall be conducted with such special compartments at their coldest settings, and the second set of tests shall be conducted with such special compartments at their warmest settings. The requirements for the warmest or coldest temperature settings of this section do not apply to features or functions associated with temperature control (such as fast chill compartments) that are initiated manually and terminated automatically within 168 hours.

2.8 The space between the back of the cabinet and a vertical surface (the test room wall or simulated wall) shall be the minimum distance in accordance with the manufacturer's instructions. However, the clearance shall not be greater than 2 inches (51 mm) from the plane of the cabinet's back panel to the vertical surface. If permanent rear spacers extend further than this distance, the appliance shall be located with the spacers in contact with the vertical surface.

2.9 Steady-State Condition. Steady-state conditions exist if the temperature measurements in all measured compartments taken at 4-minute intervals or less during a stabilization period are not changing at a rate greater than 0.042 °F (0.023 °C) per hour as determined by the applicable condition of A or B, described below.

A. The average of the measurements during a 2-hour period if no cycling occurs or during a number of complete repetitive compressor cycles occurring through a period of no less than 2 hours is compared to the average over an equivalent time period with 3 hours elapsing between the two measurement periods.

B. If A above cannot be used, the average of the measurements during a number of complete repetitive compressor cycles occurring through a period of no less than 2 hours and including the last complete cycle before a defrost period (or if no cycling occurs, the average of the measurements during the last 2 hours before a defrost period) are compared to the same averaging period before the following defrost period.

2.10 Exterior Air for Externally Vented Refrigerator or Refrigerator-Freezer. An exterior air source shall be provided with adjustable temperature and pressure capabilities. The exterior air temperature shall be adjustable from 30 ± 1 °F (1.7 ± 0.6 °C) to 90 ± 1 °F (32.2 ± 0.6 °C).

2.10.1 Air Duct. The exterior air shall pass from the exterior air source to the test unit through an insulated air duct.

2.10.2 Air Temperature Measurement. The air temperature entering the condenser or condenser/compressor compartment shall be maintained to ± 3 °F (1.7 °C) during the stabilization and test periods and shall be measured at the inlet point of the condenser or condenser/compressor compartment (''condenser inlet''). Temperature measurements shall be taken from at least three temperature sensors or one sensor per 4 square inches (25.8 square cm) of the air duct cross-sectional area, whichever is greater, and shall be averaged. For a unit that has a condenser air fan, a minimum of three temperature sensors at the condenser fan discharge shall be required. Temperature sensors shall be arranged to be at the centers of equally divided cross-sectional areas. The exterior air temperature, at its source, shall be measured and maintained to ± 1 °F (0.6 °C) during the test period. The temperature measuring devices shall have an error no greater than ± 0.5 °F (± 0.3 °C). Measurements of the air temperature during the test period shall be taken at regular intervals not to exceed 4 minutes.

2.10.3 Exterior Air Static Pressure. The exterior air static pressure at the inlet point of the unit shall be adjusted to maintain a negative pressure of 0.20″ ± 0.05″ water column (62 Pascals ± 12.5 Pascals) for all air flow rates supplied to the unit. The pressure sensor shall be located on a straight duct with a distance of at least 7.5 times the diameter of the duct upstream and a distance of at least 3 times the diameter of the duct downstream. There shall be four static pressure taps at 90° angles apart. The four pressures shall be averaged by interconnecting the four pressure taps. The air pressure measuring instrument shall have an error no greater than 0.01'' water column (2.5 Pascals).

3. Test Control Settings

3.1 Model with no User Operable Temperature Control. A test shall be performed to measure the compartment temperatures and energy use. A second test shall be performed with the temperature control electrically short circuited to cause the compressor to run continuously.

3.2 Models with User Operable Temperature Control. Testing shall be performed in accordance with one of the following sections using the following standardized temperatures:

All-Refrigerator: 39 °F (3.9 °C) fresh food compartment temperature;

Refrigerator: 15 °F (−9.4 °C) freezer compartment temperature, 39 °F (3.9 °C) fresh food compartment temperature;

Refrigerator-Freezer: 0 °F (−17.8 °C) freezer compartment temperature, 39 °F (3.9 °C) fresh food compartment temperature.

For the purposes of comparing compartment temperatures with standardized temperatures, as described in sections 3.2.1 and 3.2.2, the freezer compartment temperature shall be as specified in section 5.1.4, and the fresh food compartment temperature shall be as specified in section 5.1.3.

3.2.1 A first test shall be performed with all compartment temperature controls set at their median position midway between their warmest and coldest settings. For mechanical control systems, knob detents shall be mechanically defeated if necessary to attain a median setting. For electronic control systems, the test shall be performed with all compartment temperature controls set at the average of the coldest and warmest settings—if there is no setting equal to this average, the setting closest to the average shall be used. If there are two such settings equally close to the average, the higher of these temperature control settings shall be used. A second test shall be performed with all controls set at their warmest setting or all controls set at their coldest setting (not electrically or mechanically bypassed). For all-refrigerators, this setting shall be the appropriate setting that attempts to achieve compartment temperatures measured during the two tests which bound (i.e., one is above and one is below) the standardized temperature for all-refrigerators. For refrigerators and refrigerator-freezers, the second test shall be conducted with all controls at their coldest setting, unless all compartment temperatures measured during the first part of the test are lower than the standardized temperatures, in which case the second test shall be conducted with all controls at their warmest setting. Refer to Table 1 for all-refrigerators or Table 2 for refrigerators with freezer compartments and refrigerator-freezers to determine which test results to use in the energy consumption calculation. If any compartment is warmer than its standardized temperature for a test with all controls at their coldest position, the tested unit fails the test and cannot be rated.

TABLE 1—TEMPERATURE SETTINGS FOR ALL-REFRIGERATORS

First test		Second test		Energy calculation based on:
Settings	Results	Settings	Results	
Mid	Low	Warm	Low	Second Test Only.
			High	First and Second Tests.

TABLE 1—TEMPERATURE SETTINGS FOR ALL-REFRIGERATORS—Continued

First test		Second test		Energy calculation based on:
Settings	Results	Settings	Results	
	High	Cold	Low	First and Second Tests.
			High	No Energy Use Rating.

TABLE 2—TEMPERATURE SETTINGS FOR REFRIGERATORS WITH FREEZER COMPARTMENTS AND REFRIGERATOR-FREEZERS

First test		Second test		Energy calculation based on:
Settings	Results	Settings	Results	
Fzr Mid FF Mid	Fzr Low FF Low	Fzr Warm FF Warm	Fzr Low FF Low	Second Test Only.
			Fzr Low FF High	First and Second Tests.
			Fzr High FF Low	First and Second Tests.
			Fzr High FF High	First and Second Tests.
	Fzr Low FF High	Fzr Cold FF Cold	Fzr Low FF High	No Energy Use Rating.
			Fzr Low FF Low	First and Second Tests.
	Fzr High FF Low	Fzr Cold FF Cold	Fzr High FF Low	No Energy Use Rating.
			Fzr Low FF Low	First and Second Tests.
	Fzr High FF High	Fzr Cold FF Cold	Fzr Low FF Low	First and Second Tests.
			Fzr Low FF High	No Energy Use Rating.
			Fzr High FF Low	No Energy Use Rating.
			Fzr High FF High	No Energy Use Rating.

Notes: Fzr = Freezer Compartment, FF = Fresh Food Compartment.

3.2.2 Alternatively, a first test may be performed with all temperature controls set at their warmest setting. If all compartment temperatures are below the appropriate standardized temperatures, then the result of this test alone will be used to determine energy consumption. If this condition is not met, then the unit shall be tested in accordance with 3.2.1.

3.2.3 Temperature Settings for Separate Auxiliary Convertible Compartments. For separate auxiliary convertible compartments tested as freezer compartments, the median setting shall be within 2 °F (1.1 °C) of the standardized temperature, and the warmest setting shall be above 5 °F (−15 °C). For separate auxiliary convertible compartments tested as fresh food compartments, the median setting shall be within 2 °F (1.1 °C) of the standardized temperature, and the coldest setting shall be below 34 °F (1.1 °C). For compartments where control settings are not expressed as particular temperatures, the measured temperature of the convertible compartment rather than the settings shall meet the specified criteria.

4. Test Period

Tests shall be performed by establishing the conditions set forth in section 2, and using the control settings set forth in section 3.

4.1 Nonautomatic Defrost. If the model being tested has no automatic defrost system, the test time period shall start after steady-state conditions have been achieved and be no less than 3 hours in duration. During the test period, the compressor motor shall complete two or more whole compressor cycles. (A compressor cycle is a complete ''on'' and a complete ''off'' period of the motor). If no ''off'' cycling will occur, as determined during the stabilization period, the test period shall be 3 hours. If incomplete cycling occurs (i.e. less than two compressor cycles during a 24-hour period), the results of the 24-hour period shall be used.

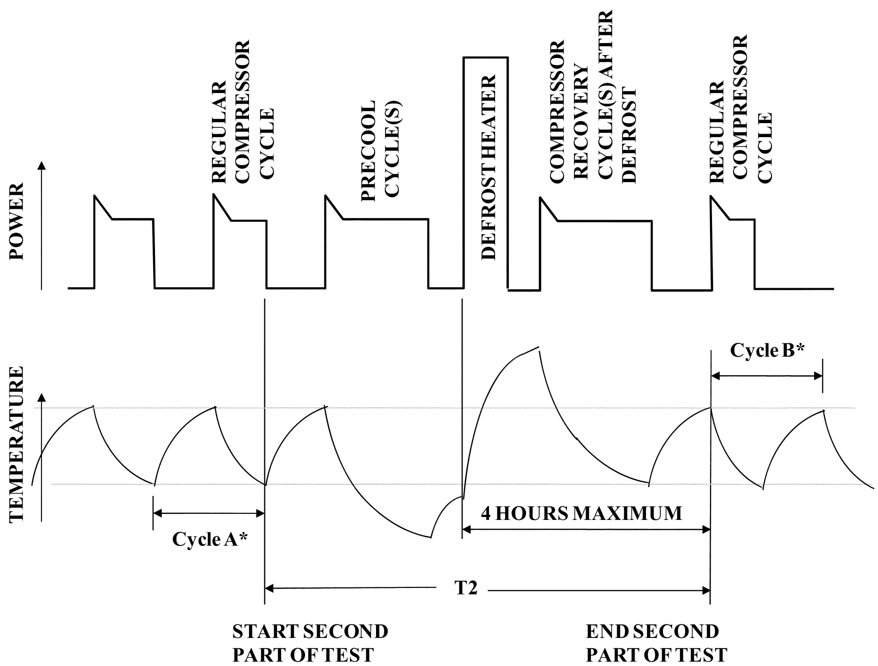
4.2 Automatic Defrost. If the model being tested has an automatic defrost system, the test time period shall start after steady-state conditions have been achieved and be from one point during a defrost period to the same point during the next defrost period. If the model being tested has a long-time automatic defrost system, the alternative provisions of 4.2.1 may be used. If the model being tested has a variable defrost control, the provisions of section 4.2.2 shall apply. If the model has a dual compressor system with automatic defrost for both systems, the provisions of 4.2.3 shall apply. If the model being tested has long-time automatic or variable defrost control involving multiple defrost cycle types, such as for a product with a single compressor and two or more evaporators in which the evaporators are defrosted at different frequencies, the provisions of section 4.2.4 shall apply. If the model being tested has multiple defrost cycle types for which compressor run time between defrosts is a fixed time of less than 14 hours for all such cycle types, and for which the compressor run time between defrosts for different defrost cycle types are equal to or multiples of each other, the test time period shall be from one point of the defrost cycle type with the longest compressor run time between defrosts to the same point during the next occurrence of this defrost cycle type. For such products not using the section 4.2.4 procedures, energy consumption shall be calculated as described in section 5.2.1.1.

4.2.1 Long-time Automatic Defrost. If the model being tested has a long-time automatic defrost system, the two-part test described in this section may be used. The first part is a stable period of compressor operation that includes no portions of the defrost cycle, such as precooling or recovery, that is otherwise the same as the test for a unit having no defrost provisions (section 4.1). The second part is designed to capture the energy consumed during all of the events occurring with the defrost control sequence that are outside of stable operation.

4.2.1.1 Cycling Compressor System. For a system with a cycling compressor, the second part starts at the termination of the last regular compressor ''on'' cycle. The average temperature of the compartment measured from the termination of the previous compressor ''on'' cycle to the termination of the last regular compressor ''on'' cycle must be within 0.5 °F (0.3 °C) of the average temperature of the compartment measured for the first part of the test. If any compressor cycles occur prior to the defrost heater being energized that cause the average temperature in the compartment to deviate from the first part temperature by more than 0.5 °F (0.3 °C), these compressor cycles are not considered regular compressor cycles and must be included in the second part of the test. As an example, a ''precool'' cycle, which is an extended compressor cycle that lowers the compartment temperature prior to energizing the defrost heater, must be included in the second part of the test. The test period for the second part of the test ends at the initiation of the first regular compressor cycle after the compartment temperatures have fully recovered to their stable conditions. The average temperature of the compartment measured from this initiation of the first regular compressor ''on'' cycle until the initiation of the next regular compressor ''on'' cycle must be within 0.5 °F (0.3 °C) of the average temperature of the compartment measured for the first part of the test. The second part of the test may be terminated after 4 hours if the above conditions cannot be met. See Figure 1.

FIGURE 1

Long-time Automatic Defrost Diagram for Cycling Compressors

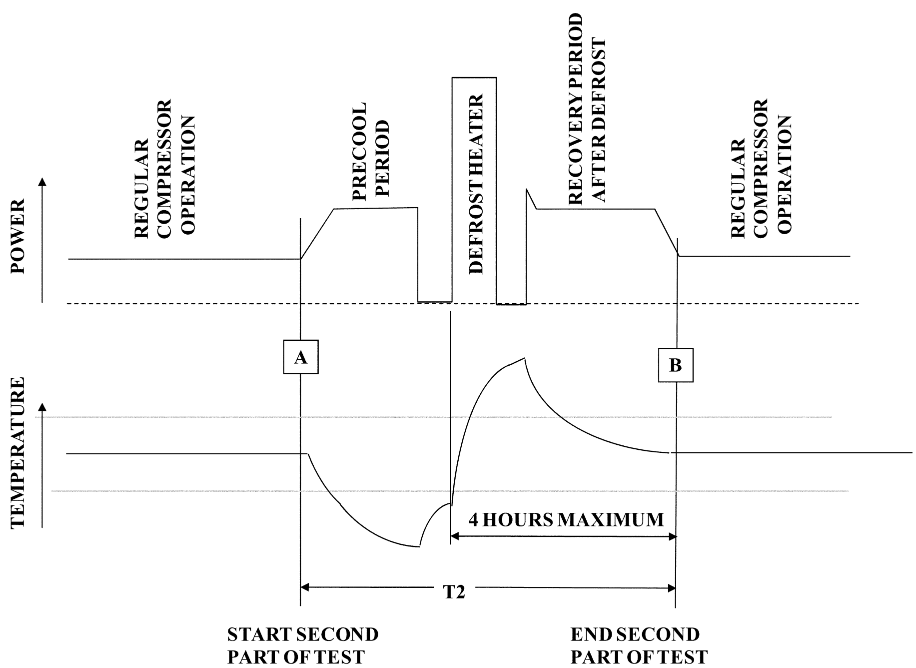


***Average compartment temperature during cycles A & B must be within 0.5 ˚F of the average temperature for the first part of the test. This requirement does not apply for cycle B if the 4 hour limit is reached.**

4.2.1.2 Non-cycling Compressor System. For a system with a non-cycling compressor, the second part starts at a time before defrost during stable operation when the compartment temperature is within 0.5 °F (0.3 °C) of the average temperature of the compartment measured for the first part of the test. The second part stops at a time after defrost during stable operation when the compartment temperature is within 0.5 °F (0.3 °C) of the average temperature of the compartment measured for the first part of the test. The second part of the test may be terminated after 4 hours if the above conditions cannot be met. *See* Figure 2.

FIGURE 2

Long-time Automatic Defrost Diagram for Non-Cycling Compressors



***Average compartment temperature at times A & B must be within 0.5 ˚F of the average temperature for the first part of the test. This requirement does not apply for time B if the 4 hour limit is reached.**

4.2.2 Variable Defrost Control. If the model being tested has a variable defrost control system, the test shall consist of the same two parts as the test for long-time automatic defrost (section 4.2.1).

4.2.3 Dual Compressor Systems with Automatic Defrost. If the model being tested has separate compressor systems for the refrigerator and freezer sections, each with its own automatic defrost system, then the two-part method in 4.2.1 shall be used. The second part of the method will be conducted separately for each automatic defrost system. The components (compressor, fan motors, defrost heaters, anti-sweat heaters, etc.) associated with each system will be identified and their energy consumption will be separately measured during each test.

4.2.4 Systems with Multiple Defrost Frequencies. This section applies to models with long-time automatic or variable defrost control with multiple defrost cycle types, such as models with single compressors and multiple evaporators in which the evaporators have different defrost frequencies. The two-part method in 4.2.1 shall be used. The second part of the method will be conducted separately for each distinct defrost cycle type. For defrost cycle types involving the defrosting of both fresh food and freezer compartments, the freezer compartment temperature shall be used to determine test period start and stop times.

5. Test Measurements

5.1 Temperature Measurements. Temperature measurements shall be made at the locations prescribed in Figures 5.1 and 5.2 of HRF–1–2008 (incorporated by reference; *see* §430.3) and shall be accurate to within ± 0.5 °F (0.3 °C). No freezer temperature measurements need be taken in an all-refrigerator model.

If the interior arrangements of the cabinet do not conform with those shown in Figure 5.1 and 5.2 of HRF–1–2008, the product may be tested by relocating the temperature sensors from the locations specified in the figures to avoid interference with hardware or components within the cabinet, in which case the specific locations used for the temperature sensors shall be noted in the test data records maintained by the manufacturer in accordance with 10 CFR 429.14, and the certification report shall indicate that non-standard sensor locations were used.

5.1.1 Measured Temperature. The measured temperature of a compartment is to be the average of all sensor temperature readings taken in that compartment at a particular point in time. Measurements shall be taken at regular intervals not to exceed 4 minutes.

5.1.2 Compartment Temperature. The compartment temperature for each test period shall be an average of the measured temperatures taken in a compartment during the test period as defined in section 4. For long-time automatic defrost models, compartment temperatures shall be those measured in the first part of the test period specified in section 4.2.1. For models with variable defrost controls, compartment temperatures shall be those measured in the first part of the test period specified in section 4.2.2.

5.1.3 Fresh Food Compartment Temperature. The fresh food compartment temperature shall be calculated as:

$$TR = \frac{\sum_{i=1}^{R}(TR_i) \times (VR_i)}{\sum_{i=1}^{R}(VR_i)}$$

Where:

R is the total number of applicable fresh food compartments, which include the first fresh food compartment and any number of separate auxiliary fresh food compartments (including separate auxiliary convertible compartments tested as fresh food compartments in accordance with section 2.7);

TR_i is the compartment temperature of fresh food compartment ''i'' determined in accordance with section 5.1.2; and

VR_i is the volume of fresh food compartment ''i''.

5.1.4 Freezer Compartment Temperature. The freezer compartment temperature shall be calculated as:

$$TF = \frac{\sum_{i=1}^{F}(TF_i) \times (VF_i)}{\sum_{i=1}^{F}(VF_i)}$$

Where:

F is the total number of applicable freezer compartments, which include the first freezer compartment and any number of separate auxiliary freezer compartments (including separate auxiliary convertible compartments tested as freezer compartments in accordance with section 2.7);

TF_i is the compartment temperature of freezer compartment ''i'' determined in accordance with section 5.1.2; and

VF_i is the volume of freezer compartment ''i''.

5.2 Energy Measurements

5.2.1 Per-Day Energy Consumption. The energy consumption in kilowatt-hours per day, ET, for each test period shall be the energy expended during the test period as specified in section 4 adjusted to a 24-hour period. The adjustment shall be determined as follows.

5.2.1.1 Nonautomatic and Automatic Defrost Models. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = EP \times 1440/T$

Where:

ET = test cycle energy expended in kilowatt-hours per day;

EP = energy expended in kilowatt-hours during the test period;

T = length of time of the test period in minutes; and

1440 = conversion factor to adjust to a 24-hour period in minutes per day.

5.2.1.2 Long-time Automatic Defrost. If the two-part test method is used, the energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (1440 \times EP1/T1) + (EP2 - (EP1 \times T2/T1)) \times (12/CT)$

Where:

ET and 1440 are defined in 5.2.1.1;

EP1 = energy expended in kilowatt-hours during the first part of the test;

EP2 = energy expended in kilowatt-hours during the second part of the test;

T1 and T2 = length of time in minutes of the first and second test parts respectively;

CT = defrost timer run time or compressor run time between defrosts in hours required to cause it to go through a complete cycle, rounded to the nearest tenth of an hour; and

12 = factor to adjust for a 50-percent run time of the compressor in hours per day.

5.2.1.3 Variable Defrost Control. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (1440 \times EP1/T1) + (EP2 - (EP1 \times T2/T1)) \times (12/CT)$,

Where:

1440 is defined in 5.2.1.1 and EP1, EP2, T1, T2, and 12 are defined in 5.2.1.2;

$CT = (CT_L \times CT_M)/(F \times (CT_M - CT_L) + CT_L)$;

CT_L = least or shortest compressor run time between defrosts in hours rounded to the nearest tenth of an hour (greater than or equal to 6 but less than or equal to 12 hours);

CT_M = maximum compressor run time between defrosts in hours rounded to the nearest tenth of an hour (greater than CT_L but not more than 96 hours);

F = ratio of per day energy consumption in excess of the least energy and the maximum difference in per-day energy consumption and is equal to 0.20

For variable defrost models with no values for CT_L and CT_M in the algorithm, the default values of 12 and 84 shall be used, respectively.

5.2.1.4 Dual Compressor Systems with Dual Automatic Defrost. The two-part test method in section 4.2.4 must be used, and the energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (1440 \times EP1/T1) + (EP2_F - (EP_F \times T2/T1)) \times (12/CT_F) + (EP2_R - (EP_R \times T3/T1)) \times (12/CT_R)$

Where:

1440, EP1, T1, EP2, 12, and CT are defined in 5.2.1.2;

EP_F = freezer system energy in kilowatt-hours expended during the first part of the test;

$EP2_F$ = freezer system energy in kilowatt-hours expended during the second part of the test for the freezer system;

EP_R = refrigerator system energy in kilowatt-hours expended during the first part of the test;

$EP2_R$ = refrigerator system energy in kilowatt-hours expended during the second part of the test for the refrigerator system;

T2 and T3 = length of time in minutes of the second test part for the freezer and refrigerator systems respectively;

CT_F = compressor run time between freezer defrosts (in hours rounded to the nearest tenth of an hour); and

CT_R = compressor run time between refrigerator defrosts (in hours rounded to the nearest tenth of an hour).

5.2.1.5 Long-time or Variable Defrost Control for Systems with Multiple Defrost cycle Types. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$$ET = \left(1440 \times EP1/T1\right) + \sum_{i=1}^{D}\left[\left(EP2_i - \left(EP1 \times T2_i/T1\right)\right) \times \left(12/CT_i\right)\right]$$

Where:

1440 is defined in 5.2.1.1 and EP1, T1, and 12 are defined in 5.2.1.2;

i is a variable that can equal 1, 2, or more that identifies the distinct defrost cycle types applicable for the refrigerator or refrigerator-freezer;

$EP2_i$ = energy expended in kilowatt-hours during the second part of the test for defrost cycle type i;

$T2_i$ = length of time in minutes of the second part of the test for defrost cycle type i;

CT_i is the compressor run time between instances of defrost cycle type i, for long-time automatic defrost control equal to a fixed time in hours rounded to the nearest tenth of an hour, and for variable defrost control equal to $(CT_{Li} \times CT_{Mi})/(F \times (CT_{Mi} - CT_{Li}) + CT_{Li})$;

CT_{Li} = least or shortest compressor run time between instances of defrost cycle type i in hours rounded to the nearest tenth of an hour (CT_L for the defrost cycle type with the longest compressor run time between defrosts must be greater than or equal to 6 but less than or equal to 12 hours);

CT_{Mi} = maximum compressor run time between instances of defrost cycle type i in hours rounded to the nearest tenth of an hour (greater than CT_{Li} but not more than 96 hours);

For cases in which there are more than one fixed CT value (for long-time defrost models) or more than one CT_M and/or CT_L value (for variable defrost models) for a given defrost cycle type, an average fixed CT value or average CT_M and CT_L values shall be selected for this cycle type so that 12 divided by this value or values is the frequency of occurrence of the defrost cycle type in a 24-hour period, assuming 50% compressor run time.

F = default defrost energy consumption factor, equal to 0.20.

For variable defrost models with no values for CT_{Li} and CT_{Mi} in the algorithm, the default values of 12 and 84 shall be used, respectively.

D is the total number of distinct defrost cycle types.

5.3 Volume Measurements. The electric refrigerator or electric refrigerator-freezer total refrigerated volume, VT, shall be measured in accordance with HRF–1–2008, (incorporated by reference; see §430.3), section 3.30 and sections 4.2 through 4.3, and be calculated equivalent to:

$$VT = VF + VFF$$

Where:

VT = total refrigerated volume in cubic feet,
VF = freezer compartment volume in cubic feet, and
VFF = fresh food compartment volume in cubic feet.

In the case of refrigerators or refrigerator-freezers with automatic icemakers, the volume occupied by the automatic icemaker, including its ice storage bin, is to be included in the volume measurement.

5.4 Externally Vented Refrigerator or Refrigerator-Freezer Units. All test measurements for the externally vented refrigerator or refrigerator-freezer shall be made in accordance with the requirements of other sections of this appendix, except as modified in this section or other sections expressly applicable to externally vented refrigerators or refrigerator-freezers.

5.4.1 Operability of ''Thermostatic'' and ''Mixing of Air'' Controls. Before conducting energy consumption tests, the operability of thermostatic controls that permit the mixing of exterior and ambient air when exterior air temperatures are less than 60 °F (15.6 °C) must be verified. The operability of such controls shall be verified by operating the unit under ambient air temperature of 90 °F (32.2 °C) and exterior air temperature of 45 °F (7.2 °C). If the inlet air entering the condenser or condenser/compressor compartment is maintained at 60 ± 3 °F (15.6 ± 1.7 °C), energy consumption of the unit shall be measured under 5.4.2.2 and 5.4.2.3. If the inlet air entering the condenser or condenser/compressor compartment is not maintained at 60 ± 3 °F (15.6 ± 1.7 °C), energy consumption of the unit shall also be measured under 5.4.2.4.

5.4.2 Energy Consumption Tests.

5.4.2.1 Correction Factor Test. To enable calculation of a correction factor, K, two full cycle tests shall be conducted to measure energy consumption of the unit with air mixing controls disabled and the condenser inlet air temperatures set at 90 °F (32.2 °C) and 80 °F (26.7 °C). Both tests shall be conducted with all compartment temperature controls set at the position midway between their warmest and coldest settings and the anti-sweat heater switch off. Record the energy consumptions ec_{90} and ec_{80}, in kWh/day.

5.4.2.2 Energy Consumption at 90 °F. The unit shall be tested at 90 °F (32.2 °C) exterior air temperature to record the energy consumptions $(e_{90})_i$ in kWh/day. For a given setting of the anti-sweat heater, the value i corresponds to each of the two states of the compartment temperature control positions.

5.4.2.3 Energy Consumption at 60 °F. The unit shall be tested at 60 °F (26.7 °C) exterior air temperature to record the energy consumptions $(e_{60})_i$ in kWh/day. For a given setting of the anti-sweat heater, the value i corresponds to each of the two states of the compartment temperature control positions.

5.4.2.4 Energy Consumption if Mixing Controls do not Operate Properly. If the operability of temperature and mixing controls has not been verified as required under 5.4.1, the unit shall be tested at 50 °F (10.0 °C) and 30 °F (-1.1 °C) exterior air temperatures to record the energy consumptions $(e_{50})_i$ and $(e_{30})_i$. For a given setting of the anti-sweat heater, the value i corresponds to each of the two states of the compartment temperature control positions.

6. Calculation of Derived Results From Test Measurements

6.1 Adjusted Total Volume.

6.1.1 Electric Refrigerators. The adjusted total volume, VA, for electric refrigerators under test shall be defined as:

$$VA = (VF \times CR) + VFF$$

Where:

VA = adjusted total volume in cubic feet;
VF and VFF are defined in 5.3; and
CR = dimensionless adjustment factor of 1.47 for refrigerators other than all-refrigerators, or 1.0 for all-refrigerators.

6.1.2 Electric Refrigerator-Freezers. The adjusted total volume, VA, for electric refrigerator-freezers under test shall be calculated as follows:

$$VA = (VF \times CRF) + VFF$$

Where:

VF and VFF are defined in 5.3 and VA is defined in 6.1.1, and
CRF = dimensionless adjustment factor of 1.76.

6.2 Average Per-Cycle Energy Consumption.

6.2.1 All-Refrigerator Models. The average per-cycle energy consumption for a cycle type, E, is expressed in kilowatt-hours per cycle to the nearest one hundredth (0.01) kilowatt-hour and shall depend upon the temperature attainable in the fresh food compartment as shown below.

6.2.1.1 If the fresh food compartment temperature is always below 39.0 °F (3.9 °C), the average per-cycle energy consumption shall be equivalent to:

E = ET1

Where:

ET is defined in 5.2.1; and
The number 1 indicates the test period during which the highest fresh food compartment temperature is measured.

6.2.1.2 If one of the fresh food compartment temperatures measured for a test period is greater than 39.0 °F (3.9 °C), the average per-cycle energy consumption shall be equivalent to:

$E = ET1 + ((ET2 - ET1) \times (39.0 - TR1)/(TR2 - TR1))$

Where:

ET is defined in 5.2.1;
TR = fresh food compartment temperature determined according to 5.1.3 in degrees F;
The numbers 1 and 2 indicate measurements taken during the first and second test period as appropriate; and
39.0 = standardized fresh food compartment temperature in degrees F.

6.2.2 Refrigerators and Refrigerator-Freezers. The average per-cycle energy consumption for a cycle type, E, is expressed in kilowatt-hours per-cycle to the nearest one hundredth (0.01) kilowatt-hour and shall be defined in one of the following ways as applicable.

6.2.2.1 If the fresh food compartment temperature is at or below 39 °F (3.9 °C) in both tests and the freezer compartment temperature is at or below 15 °F (-9.4 °C) in both tests of a refrigerator or at or below 0 °F (-17.8 °C) in both tests of a refrigerator-freezer, the per-cycle energy consumption shall be:

E = ET1 + IET

Where:

ET is defined in 5.2.1;
IET, expressed in kilowatt-hours per cycle, equals 0.23 for a product with an automatic icemaker and otherwise equals 0 (zero); and
The number 1 indicates the test period during which the highest freezer compartment temperature was measured.

6.2.2.2 If the conditions of 6.2.2.1 do not exist, the per-cycle energy consumption shall be defined by the higher of the two values calculated by the following two formulas:

$E = ET1 + ((ET2 - ET1) \times (39.0 - TR1)/(TR2 - TR1)) + IET$

and

$E = ET1 + ((ET2 - ET1) \times (k - TF1)/(TF2 - TF1)) + IET$

Where:

E is defined in 6.2.1.1;
ET is defined in 5.2.1;
IET is defined in 6.2.2.1;
TR and the numbers 1 and 2 are defined in 6.2.1.2;
TF = freezer compartment temperature determined according to 5.1.4 in degrees F;
39.0 is a specified fresh food compartment temperature in degrees F; and
k is a constant 15.0 for refrigerators or 0.0 for refrigerator-freezers, each being standardized freezer compartment temperatures in degrees F.

6.2.3 Variable Anti-Sweat Heater Models. The standard cycle energy consumption of an electric refrigerator-freezer with a variable anti-sweat heater control (E_{std}), expressed in kilowatt-hours per day, shall be calculated equivalent to:

E_{std} = E + (Correction Factor) where E is determined by 6.2.1.1, 6.2.1.2, 6.2.2.1, or 6.2.2.2, whichever is appropriate, with the anti-sweat heater switch in the "off" position or, for a product without an anti-sweat heater switch, the anti-sweat heater in its lowest energy use state.
Correction Factor = (Anti-sweat Heater Power $\times$ System-loss Factor) $\times$ (24 hrs/1 day) $\times$ (1 kW/1000 W)

Where:

Anti-sweat Heater Power = 0.034 * (Heater Watts at 5%RH)
+ 0.211 * (Heater Watts at 15%RH)
+ 0.204 * (Heater Watts at 25%RH)
+ 0.166 * (Heater Watts at 35%RH)
+ 0.126 * (Heater Watts at 45%RH)
+ 0.119 * (Heater Watts at 55%RH)
+ 0.069 * (Heater Watts at 65%RH)
+ 0.047 * (Heater Watts at 75%RH)
+ 0.008 * (Heater Watts at 85%RH)
+ 0.015 * (Heater Watts at 95%RH)
Heater Watts at a specific relative humidity = the nominal watts used by all heaters at that specific relative humidity, 72 °F (22.2 °C) ambient, and DOE reference temperatures of fresh food (FF) average temperature of 39 °F (3.9 °C) and freezer (FZ) average temperature of 0 °F (−17.8 °C).
System-loss Factor = 1.3.

6.3 Externally vented refrigerator or refrigerator-freezers. Per-cycle energy consumption measurements for an externally vented refrigerator or refrigerator-freezer shall be calculated in accordance with the requirements of this appendix, as modified in sections 6.3.1–6.3.7.

6.3.1 Correction Factor. The correction factor, K, shall be calculated as:

$K = ec_{90}/ec_{80}$

Where:

ec_{90} and ec_{80} are measured in section 5.4.2.1.

6.3.2 Combining Test Results of Different Settings of Compartment Temperature Controls. For a given setting of the anti-sweat heater, follow the calculation procedures of 6.2 to combine the test results for energy consumption of the unit at different temperature control settings for each condenser inlet air temperature tested under 5.4.2.2, 5.4.2.3, and 5.4.2.4, where applicable, $(e_{90})_i$, $(e_{60})_i$, $(e_{50})_i$, and $(e_{30})_i$. The combined values, $_{90}$, $_{60}$, $_{50}$, and $_{30}$, where applicable, are expressed in kWh/day.

6.3.3 Energy Consumption Corrections. For a given setting of the anti-sweat heater, adjust the energy consumptions $_{90}$, $_{60}$, $_{50}$, and $_{30}$ calculated in 6.3.2 by multiplying the correction factor K to obtain the corrected energy consumptions per day in kWh/day:

$E_{90} = K \times {}_{90,}$
$E_{60} = K \times {}_{60,}$
$E_{50} = K \times {}_{50}$, and
$E_{30} = K \times {}_{30}$

Where:

K is determined under section 6.3.1; and $_{90}$, $_{60}$, $_{50}$, and $_{30}$ are determined under section 6.3.2.

6.3.4 Energy Profile Equation. For a given setting of the anti-sweat heater, calculate the energy consumption E_X, in kWh/day, at a specific exterior air temperature between 80 °F (26.7 °C) and 60 °F (26.7 °C) using the following equation:

$E_X = E_{60} + (E_{90} - E_{60}) \times (T_X - 60)/30$

Where:

T_X is the exterior air temperature in °F;
60 is the exterior air temperature in °F for the test of section 5.4.2.3;
30 is the difference between 90 and 60;
E_{60} and E_{90} are determined in section 6.3.3.

6.3.5 Energy Consumption at 80 °F (26.7 °C), 75 °F (23.9 °C) and 65 °F (18.3 °C). For a given setting of the anti-sweat heater, calculate the energy consumptions at 80 °F (26.7 °C), 75 °F (23.9 °C) and 65 °F (18.3 °C) exterior air temperatures, E_{80}, E_{75} and E_{65}, respectively, in kWh/day, using the equation in 6.3.4.

6.3.6 National Average Per-Cycle Energy Consumption. For a given setting of the anti-sweat heater, calculate the national average energy consumption, E_N, in kWh/day, using one of the following equations:

$E_N = 0.523 \times E_{60} + 0.165 \times E_{65} + 0.181 \times E_{75} + 0.131 \times E_{80}$, for units not tested under section 5.4.2.4; and

$E_N = 0.257 \times E_{30} + 0.266 \times E_{50} + 0.165 \times E_{65} + 0.181 \times E_{75} + 0.131 \times E_{80}$, for units tested under section 5.4.2.4

Where:

E_{30}, E_{50}, and E_{60} are defined in 6.3.3;
E_{65}, E_{75}, and E_{80} are defined in 6.3.5;
and
the coefficients 0.523, 0.165, 0.181, 0.131, 0.257 and 0.266 are weather-associated weighting factors.

6.3.7 Regional Average Per-Cycle Energy Consumption. If regional average per-cycle energy consumption is required to be calculated for a given setting of the anti-sweat heater, calculate the regional average per-cycle energy consumption, E_R, in kWh/day, for the regions in Figure 3. Use one of the following equations and the coefficients in Table A:

$E_R = a_1 \times E_{60} + c \times E_{65} + d \times E_{75} + e \times E_{80}$, for a unit that is not required to be tested under section 5.4.2.4; or

$E_R = a \times E_{30} + b \times E_{50} + c \times E_{65} + d \times E_{75} + e \times E_{80}$, for a unit tested under section 5.4.2.4

Where:

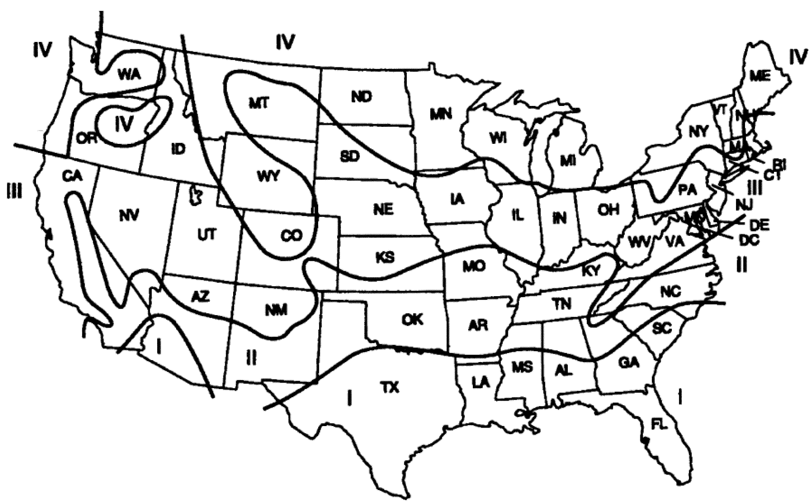
E_{30}, E_{50}, and E_{60} are defined in section 6.3.3;
E_{65}, E_{75}, and E_{80} are defined in section 6.3.5; and
a_1, a, b, c, d, and e are weather-associated weighting factors for the regions, as specified in Table A.

TABLE A—COEFFICIENTS FOR CALCULATING REGIONAL AVERAGE PER-CYCLE ENERGY CONSUMPTION

[Weighting factors]

Regions	a1	a	b	c	d	e
I	0.282	0.039	0.244	0.194	0.326	0.198
II	0.486	0.194	0.293	0.191	0.193	0.129
III	0.584	0.302	0.282	0.178	0.159	0.079
IV	0.664	0.420	0.244	0.161	0.121	0.055

Figure 3: Weather Regions for the United States



Alaska: Region IV

Hawaii: Region I

7. Test Procedure Waivers

To the extent that the procedures contained in this appendix do not provide a means for determining the energy consumption of a refrigerator or refrigerator-freezer, a manufacturer must obtain a waiver under 10 CFR 430.27 to establish an acceptable test procedure for each such product. Such instances could, for example, include situations where the test set-up for a particular refrigerator or refrigerator-freezer basic model is not clearly defined by the provisions of section 2. For details regarding the criteria and procedures for obtaining a waiver, please refer to 10 CFR 430.27.

[75 FR 78851, Dec. 16, 2010, as amended at 76 FR 12502, Mar. 7, 2011; 76 FR 24781, May 2, 2011]

APPENDIX A1 TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF ELECTRIC REFRIGERATORS AND ELECTRIC REFRIGERATOR-FREEZERS

The provisions of appendix A1 shall apply to all products manufactured prior to the effective date of any amended standards promulgated by DOE pursuant to Section 325(b)(4) of the Energy Policy and Conservation Act of 1975, as amended by the Energy Independence and Security Act of 2007 (to be codified at 42 U.S.C. 6295(b)(4)).

1. Definitions

Section 3, *Definitions*, of HRF–1–1979 (incorporated by reference; see § 430.3) applies to this test procedure.

1.1 ''Adjusted total volume'' means the sum of (i) the fresh food compartment volume as defined in HRF–1–1979 in cubic feet, and (ii) the product of an adjustment factor and the net freezer compartment volume as defined in HRF–1–1979, in cubic feet.

1.2 ''All-refrigerator'' means an electric refrigerator which does not include a compartment for the freezing and long time storage of food at temperatures below 32 °F (0.0 °C). It may include a compartment of 0.50 cubic feet capacity (14.2 liters) or less for the freezing and storage of ice.

1.3 ''Anti-sweat heater'' means a device incorporated into the design of a refrigerator or refrigerator-freezer to prevent the accumulation of moisture on exterior or interior surfaces of the cabinet.

1.4 ''Anti-sweat heater switch'' means a user-controllable switch or user interface which modifies the activation or control of anti-sweat heaters.

1.5 ''Automatic defrost'' means a system in which the defrost cycle is automatically initiated and terminated, with resumption of normal refrigeration at the conclusion of the defrost operation. The system automatically prevents the permanent formation of frost on all refrigerated surfaces. Nominal refrigerated food temperatures are maintained during the operation of the automatic defrost system.

1.6 ''Automatic icemaker'' means a device that can be supplied with water without user intervention, either from a pressurized water supply system or by transfer from a water reservoir located inside the cabinet, that automatically produces, harvests, and stores ice in a storage bin, with means to automatically interrupt the harvesting operation when the ice storage bin is filled to a pre-determined level.

1.7 ''Cycle'' means the period of 24 hours for which the energy use of an electric refrigerator or electric refrigerator-freezer is calculated as though the consumer activated compartment temperature controls were set to maintain the standardized temperatures (see section 3.2).

1.8 ''Cycle type'' means the set of test conditions having the calculated effect of operating an electric refrigerator or electric refrigerator-freezer for a period of 24 hours, with the consumer activated controls other than those that control compartment temperatures set to establish various operating characteristics.

1.9 ''Defrost cycle type'' means a distinct sequence of control whose function is to remove frost and/or ice from a refrigerated surface. There may be variations in the defrost control sequence such as the number of defrost heaters energized. Each such variation establishes a separate distinct defrost cycle type. However, defrost achieved regularly during the compressor off-cycles by warming of the evaporator without active heat addition is not a defrost cycle type.

1.10 ''Externally vented refrigerator or refrigerator-freezer'' means an electric refrigerator or electric refrigerator-freezer that has an enclosed condenser or an enclosed condenser/compressor compartment and a set of air ducts for transferring the exterior air from outside the building envelope into, through, and out of the refrigerator or refrigerator-freezer cabinet; is capable of mixing exterior air with the room air before discharging into, through, and out of the condenser or condenser/compressor compartment; may include thermostatically controlled dampers or controls that mix the exterior and room air at low outdoor temperatures and exclude exterior air when the outdoor air temperature is above 80 °F (26.7 °C) or the room air temperature; and may have a thermostatically actuated exterior air fan.

1.11 ''HRF–1–1979'' means the Association of Home Appliance Manufacturers standard for household refrigerators, combination refrigerator-freezers, and household freezers, also approved as an American National Standard as a revision of ANSI B 38.1–1970. Only sections of HRF–1–1979 (incorporated by reference; see § 430.3) specifically referenced in this test procedure are part of this test procedure. In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over HRF–1–1979.

1.12 ''Long-time Automatic Defrost'' means an automatic defrost system where successive defrost cycles are separated by 14 hours or more of compressor-operating time.

1.13 ''Separate auxiliary compartment'' means a freezer compartment or a fresh food compartment of a refrigerator or refrigerator-freezer having more than two compartments that is not the first freezer compartment or the first fresh food compartment. Access to a separate auxiliary compartment is through a separate exterior door or doors rather than through the door or doors of another compartment. Separate auxiliary compartments may be convertible (e.g., from fresh food to freezer). Separate auxiliary freezer compartments may not be larger than the first freezer compartment and separate auxiliary fresh food compartments may not be larger than the first fresh food compartment, but such size restrictions do not apply to separate auxiliary convertible compartments.

1.14 ''Special compartment'' means any compartment other than a butter conditioner, without doors directly accessible from the exterior, and with separate temperature control (such as crispers convertible to meat keepers) that is not convertible from fresh food temperature range to freezer temperature range.

1.15 ''Stabilization Period'' means the total period of time during which steady-state conditions are being attained or evaluated.

1.16 ''Standard cycle'' means the cycle type in which the anti-sweat heater control, when provided, is set in the highest energy consuming position.

1.17 ''Variable anti-sweat heater control'' means an anti-sweat heater control that varies the average power input of the anti-sweat heater(s) based on operating condition variable(s) and/or ambient condition variable(s).

1.18 ''Variable defrost control'' means an automatic defrost system in which successive defrost cycles are determined by an operating condition variable or variables other than solely compressor operating time. This includes any electrical or mechanical device performing this function. A control scheme that changes the defrost interval from a fixed length to an extended length (without any intermediate steps) is not considered a variable defrost control. A variable defrost control feature should predict the accumulation of frost on the evaporator and react accordingly. Therefore, the times between defrost should vary with different usage patterns and include a continuum of lengths of time between defrosts as inputs vary.

2. Test Conditions

2.1 Ambient Temperature. The ambient temperature shall be 90.0 ± 1 °F (32.2 ± 0.6 °C) during the stabilization period and the test period.

2.2 Operational Conditions. The electric refrigerator or electric refrigerator-freezer shall be installed and its operating conditions maintained in accordance with HRF–1–1979, (incorporated by reference; see §430.3), section 7.2 through section 7.4.3.3, except that the vertical ambient temperature gradient at locations 10 inches (25.4 cm) out from the centers of the two sides of the unit being tested is to be maintained during the test. Unless the area is obstructed by shields or baffles, the gradient is to be maintained from 2 inches (5.1 cm) above the floor or supporting platform to a height 1 foot (30.5 cm) above the unit under test. Defrost controls are to be operative. Other exceptions and provisions to the cited sections of HRF–1–1979 are noted in sections 2.3 through 2.8, and 5.1 of this appendix.

2.3 Anti-Sweat Heaters.

The anti-sweat heater switch is to be on during one test and off during a second test. In the case of an electric refrigerator-freezer with variable anti-sweat heater control, the standard cycle energy use shall be the result of the calculation described in 6.2.3.

2.4 Conditions for Automatic Defrost Refrigerator-Freezers. For automatic defrost refrigerator-freezers, the freezer compartments shall not be loaded with any frozen food packages during testing. Cylindrical metallic masses of dimensions 1.12 ± 0.25 inches (2.9 ± 0.6 cm) in diameter and height shall be attached in good thermal contact with each temperature sensor within the refrigerated compartments. All temperature measuring sensor masses shall be supported by low-thermal-conductivity supports in such a manner to ensure that there will be at least 1 inch (2.5 cm) of air space separating the thermal mass from contact with any interior surface or hardware inside the cabinet. In case of interference with hardware at the sensor locations specified in section 5.1, the sensors shall be placed at the nearest adjacent location such that there will be a 1-inch air space separating the sensor mass from the hardware.

2.5 Conditions for all-refrigerators. There shall be no load in the freezer compartment during the test.

2.6 The cabinet and its refrigerating mechanism shall be assembled and set up in accordance with the printed consumer instructions supplied with the cabinet. Set-up of the refrigerator or refrigerator-freezer shall not deviate from these instructions, unless explicitly required or allowed by this test procedure. Specific required or allowed deviations from such set-up include the following:

(a) Connection of water lines and installation of water filters are not required;

(b) Clearance requirements from surfaces of the product shall be as described in section 2.8 below;

(c) The electric power supply shall be as described in HRF–1–1979 (incorporated by reference; see §430.3) section 7.4.1;

(d) Temperature control settings for testing shall be as described in section 3 below. Settings for convertible compartments and other temperature-controllable or special compartments shall be as described in section 2.7 of this appendix;

(e) The product does not need to be anchored or otherwise secured to prevent tipping during energy testing; and

(f) All the product's chutes and throats required for the delivery of ice shall be free of packing, covers, or other blockages that may be fitted for shipping or when the icemaker is not in use.

For cases in which set-up is not clearly defined by this test procedure, manufacturers must submit a petition for a waiver (see section 7).

2.7 Compartments that are convertible (e.g., from fresh food to freezer) shall be operated in the highest energy use position. For the special case of convertible separate auxiliary compartments, this means that the compartment shall be treated as a freezer compartment or a fresh food compartment, depending on which of these represents higher energy use. Special compartments shall be tested with controls set to provide the coldest temperature. This requirement for the coldest temperature does not apply to features or functions associated with temperature control (such as fast chill compartments) that are initiated manually and terminated automatically within 168 hours.

2.8 The space between the back of the cabinet and a vertical surface (the test room wall or simulated wall) shall be the minimum distance in accordance with the manufacturer's instructions.

2.9 Steady State Condition. Steady state conditions exist if the temperature measurements in all measured compartments taken at four minute intervals or less during a stabilization period are not changing at a rate greater than 0.042 °F. (0.023 °C.) per hour as determined by the applicable condition of A or B.

A. The average of the measurements during a two hour period if no cycling occurs or during a number of complete repetitive compressor cycles through a period of no less than two hours is compared to the average over an equivalent time period with three hours elapsed between the two measurement periods.

B. If A above cannot be used, the average of the measurements during a number of complete repetitive compressor cycles through a period of no less than two hours and including the last complete cycle prior to a defrost period, or if no cycling occurs, the average of the measurements during the last two hours prior to a defrost period; are compared to the same averaging period prior to the following defrost period.

2.10 Exterior air for externally vented refrigerator or refrigerator-freezer. An exterior air source shall be provided with adjustable temperature and pressure capabilities. The exterior air temperature shall be adjustable from 35 ± 1 °F (1.7 ± 0.6 °C) to 90 ± 1 °F (32.2 ± 0.6 °C).

2.10.1 Air duct. The exterior air shall pass from the exterior air source to the test unit through an insulated air duct.

2.10.2 Air temperature measurement. The air temperature entering the condenser or condenser/compressor compartment shall be maintained to ± 3 °F (1.7 °C) during the stabilization and test periods and shall be measured at the inlet point of the condenser or condenser/compressor compartment (''condenser inlet''). Temperature measurements shall be taken from at least three temperature sensors or one sensor per 4 square inches of the air duct cross sectional area, whichever is greater, and shall be averaged. For a unit that has a condenser air fan, a minimum of three temperature sensors at the condenser fan discharge shall be required. Temperature sensors shall be arranged to be at the centers of equally divided cross sectional areas. The exterior air temperature, at its source, shall be measured and maintained to ± 1 °F (0.6 °C) during the test period. The temperature measuring devices shall have an error not greater than ± 0.5 °F (± 0.3 °C). Measurements of the air temperature during the test period shall be taken at regular intervals not to exceed four minutes.

2.10.3 Exterior air static pressure. The exterior air static pressure at the inlet point of the unit shall be adjusted to maintain a negative pressure of 0.20″ ± 0.05″ water column (62 Pa ± 12.5 Pa) for all air flow rates supplied to the unit. The pressure sensor shall be located on a straight duct with a distance of at least 7.5 times the diameter of the duct upstream and a distance of at least 3 times the diameter of the duct downstream. There shall be four static pressure taps at 90°angles apart. The four pressures shall be averaged by interconnecting the four pressure taps. The air pressure measuring instrument shall have an error not greater than 0.01″ water column (2.5 Pa).

3. Test Control Settings

3.1 Model with no user operable temperature control. A test shall be performed during which the compartment temperatures and energy use shall be measured. A second test shall be performed with the temperature control electrically short circuited to cause the compressor to run continuously.

3.2 Model with User Operable Temperature Control. Testing shall be performed in accordance with one of the following sections using the standardized temperatures of:

All-Refrigerator: 38 °F (3.3 °C) fresh food compartment temperature;

Refrigerator: 15 °F (−9.4 °C) freezer compartment temperature, 45 °F (7.2 °C) fresh food compartment temperature;

Refrigerator-Freezer: 5 °F (−15 °C) freezer compartment temperature, 45 °F (7.2 °C) fresh food compartment temperature.

For the purposes of comparing compartment temperatures with standardized temperatures, as described in sections 3.2.1 through 3.2.3, the freezer compartment temperature shall be as specified in section 5.1.4, and the fresh food compartment temperature shall be as specified in section 5.1.3.

3.2.1 A first test shall be performed with all compartment temperature controls set at their median position midway between their warmest and coldest settings. For mechanical control systems, knob detents shall be mechanically defeated if necessary to attain a median setting. For electronic control systems, the test shall be performed with all compartment temperature controls set at the average of the coldest and warmest settings—if there is no setting equal to this average, the setting closest to the average shall be used. If there are two such settings equally close to the average, the higher of these temperature control settings shall be used. A second test shall be performed with all controls set at their warmest setting or all controls set at their coldest setting (not electrically or mechanically bypassed). For all-refrigerators, this setting shall be the appropriate setting that attempts to achieve compartment temperatures measured during the two tests which bound (i.e., one is above and one is below) the standardized temperature for all-refrigerators. For refrigerators and refrigerator-freezers, the second test shall be conducted with all controls at their coldest setting, unless all compartment temperatures measured during the first part of the test are lower than the standardized temperatures, in which case the second test shall be conducted with all controls at their warmest setting. If (a) the measured temperature of any compartment with all controls set at their coldest settings is above its standardized temperature, a third test shall be performed with all controls set at their warmest settings and the result of this test shall be used with the result of the test performed with all controls set at their coldest settings to determine energy consumption. If (b) the measured temperatures of all compartments with all controls set at their warmest settings are below their standardized temperatures then the result of this test alone will be used to determine energy consumption. If neither (a) nor (b) occur, then the results of the first two tests shall be used to determine energy consumption.

3.2.2 Alternatively, a first test may be performed with all temperature controls set at their warmest setting. If the measured temperatures of all compartments for this test are below their standardized temperatures then the result of this test alone will be used to determine energy consumption. If this condition is not met, then the unit shall be tested in accordance with 3.2.1 of this appendix.

3.2.3 Alternatively, a first test may be performed with all temperature controls set at their coldest setting. If the measured temperature of any compartment for this test is above its standardized temperature, a second test shall be performed with all controls set at their warmest settings and the result of this test shall be used with the result of the test performed with all controls set at their coldest settings to determine energy consumption. If this condition is not met, then the unit shall be tested in accordance with 3.2.1 of this appendix.

3.2.4 Temperature Settings for Separate Auxiliary Convertible Compartments. For separate auxiliary convertible compartments tested as freezer compartments, the median setting shall be within 2 °F (1.1 °C) of the standardized temperature, and the warmest setting shall be above 10 °F (−12.2 °C). For separate auxiliary convertible compartments tested as fresh food compartments, the median setting shall be within 2 °F (1.1 °C) of the standardized temperature, and the coldest setting shall be below 40 °F (4.4 °C). For compartments where control settings are not expressed as particular temperatures, the measured temperature of the convertible compartment rather than the settings shall meet the specified criteria.

4. Test Period

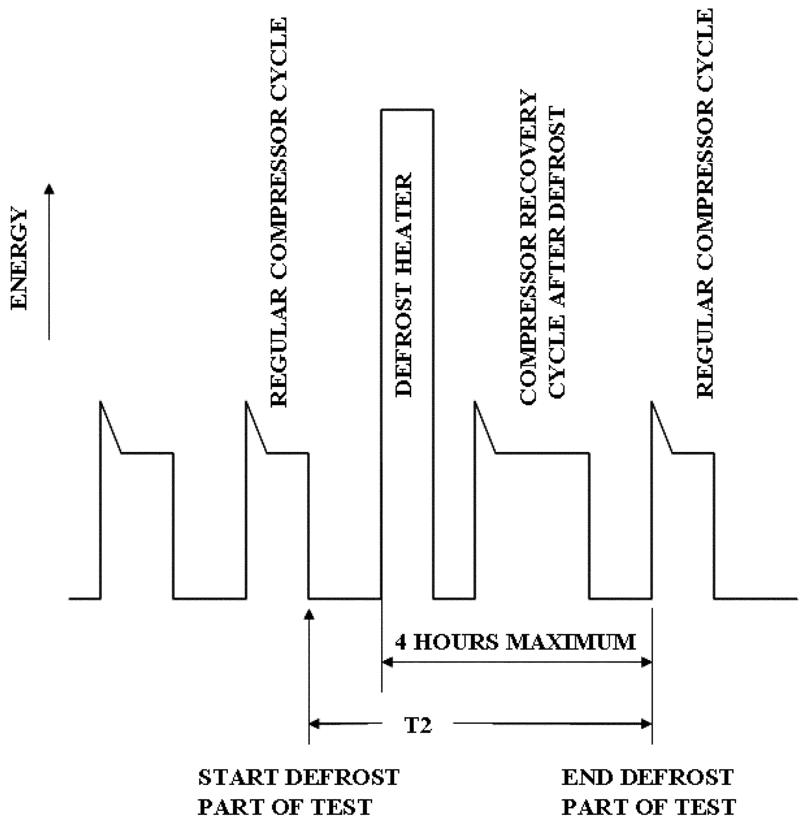
Tests shall be performed by establishing the conditions set forth in section 2, and using the control settings set forth in section 3.

4.1 Nonautomatic Defrost. If the model being tested has no automatic defrost system, the test time period shall start after steady-state conditions have been achieved and be no less than 3 hours in duration. During the test period, the compressor motor shall complete two or more whole compressor cycles. (A compressor cycle is a complete ''on'' and a complete ''off'' period of the motor). If no ''off'' cycling will occur, as determined during the stabilization period, the test period shall be 3 hours. If incomplete cycling occurs (i.e. less than two compressor cycles during a 24-hour period), the results of the 24-hour period shall be used.

4.2 Automatic Defrost. If the model being tested has an automatic defrost system, the test time period shall start after steady-state conditions have been achieved and be from one point during a defrost period to the same point during the next defrost period. If the model being tested has a long-time automatic defrost system, the alternative provisions of 4.2.1 may be used. If the model being tested has a variable defrost control, the provisions of section 4.2.2 shall apply. If the model has a dual compressor system with automatic defrost for both systems, the provisions of 4.2.3 shall apply.

4.2.1 Long-time Automatic Defrost. If the model being tested has a long-time automatic defrost system, the test time period may consist of two parts. The first part would be the same as the test for a unit having no defrost provisions (section 4.1). The second part would start when a defrost cycle is initiated when the compressor ''on'' cycle is terminated prior to start of the defrost heater and terminates at the second turn ''on'' of the compressor or 4 hours from the initiation of the defrost heater, whichever comes first. See diagram in Figure 1 to this section.

Figure 1
Long-time Automatic Defrost Diagram



4.2.2 Variable Defrost Control. If the model being tested has a variable defrost control system, the test shall consist of the same two parts as the test for long-time automatic defrost (section 4.2.1).

4.2.3 Dual Compressor Systems with Automatic Defrost. If the model being tested has separate compressor systems for the refrigerator and freezer sections, each with its own automatic defrost system, then the two-part method in 4.2.1 shall be used. The second part of the method will be conducted separately for each automatic defrost system. The components (compressor, fan motors, defrost heaters, anti-sweat heaters, etc.) associated with each system will be identified and their energy consumption will be separately measured during each test.

5. Test Measurements

5.1 Temperature Measurements. Temperature measurements shall be made at the locations prescribed in Figures 7.1 and 7.2 of HRF–1–1979 (incorporated by reference; see §430.3) and shall be accurate to within ± 0.5 °F (0.3 °C). No freezer temperature measurements need be taken in an all-refrigerator model. If the interior arrangements of the cabinet do not conform with those shown in Figure 7.1 and 7.2 of HRF–1–1979, the product may be tested by relocating the temperature sensors from the locations specified in the figures to avoid interference with hardware or components within the cabinet, in which case the specific locations used for the temperature sensors shall be noted in the test data records maintained by the manufacturer in accordance with 10 CFR 429.14, and the certification report shall indicate that non-standard sensor locations were used.

5.1.1 Measured Temperature. The measured temperature of a compartment is to be the average of all sensor temperature readings taken in that compartment at a particular time. Measurements shall be taken at regular intervals not to exceed four minutes.

5.1.2 Compartment Temperature. The compartment temperature for each test period shall be an average of the measured temperatures taken in a compartment during one or more complete compressor cycles. One compressor cycle is one complete motor "on" and one complete motor "off" period. For long-time automatic defrost models, compartment temperatures shall be those measured in the first part of the test period specified in section 4.2.1. For models with variable defrost controls, compartment temperatures shall be those measured in the first part of the test period specified in section 4.2.2.

5.1.2.1 The number of complete compressor cycles over which the measured temperatures in a compartment are to be averaged to determine compartment temperature shall be equal to the number of minutes between measured temperature readings, rounded up to the next whole minute or a number of complete compressor cycles over a time period exceeding 1 hour, whichever is greater. One of the compressor cycles shall be the last complete compressor cycle during the test period.

5.1.2.2 If no compressor cycling occurs, the compartment temperature shall be the average of the measured temperatures taken during the last 32 minutes of the test period.

5.1.2.3 If incomplete compressor cycling occurs, the compartment temperatures shall be the average of the measured temperatures taken during the last three hours of the last complete compressor "on" period.

5.1.3 Fresh Food Compartment Temperature. The fresh food compartment temperature shall be calculated as:

$$TR = \frac{\sum_{i=1}^{R}(TR_i) \times (VR_i)}{\sum_{i=1}^{R}(VR_i)}$$

Where:

R is the total number of applicable fresh food compartments, which include the first fresh food compartment and any number of separate auxiliary fresh food compartments (including separate auxiliary convertible compartments tested as fresh food compartments in accordance with section 2.7);

TR_i is the compartment temperature of fresh food compartment "i" determined in accordance with section 5.1.2; and

VR_i is the volume of fresh food compartment "i".

5.1.4 Freezer Compartment Temperature. The freezer compartmenttemperature shall be calculated as:

$$TF = \frac{\sum_{i=1}^{F}(TF_i) \times (VF_i)}{\sum_{i=1}^{F}(VF_i)}$$

Where:

F is the total number of applicable freezer compartments, which include the first freezer compartment and any number of separate auxiliary freezer compartments (including separate auxiliary convertible compartments tested as freezer compartments in accordance with section 2.7);

TF_i is the compartment temperature of freezer compartment "i" determined in accordance with section 5.1.2; and

VF_i is the volume of freezer compartment "i".

5.2 Energy Measurements

5.2.1 Per-day Energy Consumption. The energy consumption in kilowatt-hours per day for each test period shall be the energy expended during the test period as specified in section 4 adjusted to a 24-hour period. The adjustment shall be determined as follows:

5.2.1.1 Nonautomatic and Automatic Defrost Models. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = EP \times 1440/T$

Where:

ET = test cycle energy expended in kilowatt-hours per day;
EP = energy expended in kilowatt-hours during the test period;
T = length of time of the test period in minutes; and
1440 = conversion factor to adjust to a 24-hour period in minutes per day.

5.2.1.2 Long-time Automatic Defrost. If the two-part test method is used, the energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (1440 \times EP1/T1) + (EP2 - (EP1 \times T2/T1)) \times (12/CT)$

Where:

ET and 1440 are defined in 5.2.1.1;
EP1 = energy expended in kilowatt-hours during the first part of the test;
EP2 = energy expended in kilowatt-hours during the second part of the test;
T1 and T2 = length of time in minutes of the first and second test parts respectively;
CT = defrost timer run time or compressor run time between defrosts in hours required to cause it to go through a complete cycle, rounded to the nearest tenth of an hour; and
12 = factor to adjust for a 50-percent run time of the compressor in hours per day.

5.2.1.3 Variable Defrost Control. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (1440 \times EP1/T1) + (EP2 - (EP1 \times T2/T1)) \times (12/CT)$,

Where:

1440 is defined in 5.2.1.1 and EP1, EP2, T1, T2, and 12 are defined in 5.2.1.2;
$CT = (CT_L \times CT_M)/(F \times (CT_M - CT_L) + CT_L)$;
CT_L = least or shortest compressor run time between defrosts in hours rounded to the nearest tenth of an hour (greater than or equal to 6 but less than or equal to 12 hours);
CT_M = maximum compressor run time between defrosts in hours rounded to the nearest tenth of an hour (greater than CT_L but not more than 96 hours);
F = ratio of per day energy consumption in excess of the least energy and the maximum difference in per-day energy consumption and is equal to 0.20;
For variable defrost models with no values for CT_L and CT_M in the algorithm, the default values of 12 and 84 shall be used, respectively.

5.2.1.4 Dual Compressor Systems with Dual Automatic Defrost. The two-part test method in section 4.1.2.4 must be used, and the energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (1440 \times EP1/T1) + (EP2_F - (EP_F \times T2/T1)) \times (12/CT_F) + (EP2_R - (EP_R \times T3/T1)) \times (12/CT_R)$

Where:

1440, EP1, T1, EP2, 12, and CT are defined in 5.2.1.2;
EP_F = freezer system energy in kilowatt-hours expended during the first part of the test;
$EP2_F$ = freezer system energy in kilowatt-hours expended during the second part of the test for the freezer system;
EP_R= refrigerator system energy in kilowatt-hours expended during the first part of the test;
$EP2_R$ = refrigerator system energy in kilowatt-hours expended during the second part of the test for the refrigerator system;
T2 and T3 = length of time in minutes of the second test part for the freezer and refrigerator systems respectively;
CT_F = compressor run time between freezer defrosts (in hours rounded to the nearest tenth of an hour); and
CT_R = compressor run time between refrigerator defrosts (in hours rounded to the nearest tenth of an hour).

5.3 Volume measurements. The electric refrigerator or electric refrigerator-freezer total refrigerated volume, VT, shall be measured in accordance with HRF–1–1979, section 3.20 and sections 4.2 through 4.3 and be calculated equivalent to:

VT=VF+VFF

where

VT=total refrigerated volume in cubic feet,
VF=freezer compartment volume in cubic feet, and
VFF=fresh food compartment volume in cubic feet.

5.4 Externally vented refrigerator or refrigerator-freezer units. All test measurements for the externally vented refrigerator or refrigerator-freezer shall be made in accordance with the requirements of other sections of this appendix, except as modified in this section 5.4 or other sections expressly applicable to externally vented refrigerators or refrigerator-freezers.

5.4.1 Operability of thermostatic and mixing of air controls. Prior to conducting energy consumption tests, the operability of thermostatic controls that permit the mixing of exterior and ambient air when exterior air temperatures are less than 60 °F must be verified. The operability of such controls shall be verified by operating the unit under ambient air temperature of 90 °F and exterior air temperature of 45 °F. If the inlet air entering the condenser or condenser/compressor compartment is maintained at 60 °F, plus or minus three degrees, energy consumption of the unit shall be measured under 5.4.2.2 and 5.4.2.3. If the inlet air entering the condenser or condenser/compressor compartment is not maintained at 60 °F, plus or minus three degrees, energy consumption of the unit shall also be measured under 5.4.2.4.

5.4.2 Energy consumption tests.

5.4.2.1 Correction factor test. To enable calculation of a correction factor, K, two full cycle tests shall be conducted to measure energy consumption of the unit with air mixing controls disabled and the condenser inlet air temperatures set at 90 °F (32.2 °C) and 80 °F (26.7 °C). Both tests shall be conducted with all compartment temperature controls set at the position midway between their warmest and coldest settings and the anti-sweat heater switch off. Record the energy consumptions ec_{90} and ec_{80}, in kWh/day.

5.4.2.2 Energy consumption at 90 °F. The unit shall be tested at 90 °F (32.2 °C) exterior air temperature to record the energy consumptions $(e_{90})_i$ in kWh/day. For a given setting of the anti-sweat heater, i corresponds to each of the two states of the compartment temperature control positions.

5.4.2.3 Energy consumption at 60 °F. The unit shall be tested at 60 °F (26.7 °C) exterior air temperature to record the energy consumptions $(e_{60})_i$ in kWh/day. For a given setting of the anti-sweat heater, i corresponds to each of the two states of the compartment temperature control positions.

5.4.2.4 Energy consumption if mixing controls do not operate properly. If the operability of temperature and mixing controls has not been verified as required under 5.4.1, the unit shall be tested at 50 °F (10.0 °C) and 30 °F (−1.1 °C) exterior air temperatures to record the energy consumptions $(e_{50})_i$ and $(e_{30})_i$. For a given setting of the anti-sweat heater, i corresponds to each of the two states of the compartment temperature control positions.

6. Calculation of Derived Results from Test Measurements

6.1 Adjusted Total Volume.

6.1.1 Electric refrigerators. The adjusted total volume, VA, for electric refrigerators under test shall be defined as:

$$VA=(VF\times CR)+VFF$$

where

VA=adjusted total volume in cubic feet,

VF and VFF are defined in 5.3, and

CR=adjustment factor of 1.44 for refrigerators other than all-refrigerators, or 1.0 for all-refrigerators, dimensionless,

6.1.2 Electric refrigerator-freezers. The adjusted total volume, VA, for electric refrigerator-freezers under test shall be calculated as follows:

$$VA=(VF\times CRF)+VFF$$

where

VF and VFF are defined in 5.3 and VA is defined in 6.1.1,

CRF=adjustment factor of 1.63, dimensionless,

6.2 Average Per-Cycle Energy consumption.

6.2.1 All-refrigerator Models. The average per-cycle energy consumption for a cycle type is expressed in kilowatt-hours per cycle to the nearest one hundredth (0.01) kilowatt-hour and shall depend upon the temperature attainable in the fresh food compartment as shown below.

6.2.1.1 If the fresh food compartment temperature is always below 38.0 °F. (3.3 °C.), the average per-cycle energy consumption shall be equivalent to:

$$E=ET1$$

where

E=Total per-cycle energy consumption in kilowatt-hours per day,

ET is defined in 5.2.1, and Number 1 indicates the test period during which the highest fresh food compartment temperature is measured.

6.2.1.2 If one of the fresh food compartment temperatures measured for a test period is greater than 38.0 °F (3.3 °C), the average per-cycle energy consumption shall be equivalent to:

$$E = ET1 + ((ET2-ET1) \times (38.0 - TR1)/(TR2 - TR1))$$

Where:

E is defined in 6.2.1.1;

ET is defined in 5.2.1;

TR = Fresh food compartment temperature determined according to 5.1.3 in degrees F;

The numbers 1 and 2 indicate measurements taken during the first and second test period as appropriate; and

38.0 = Standardized fresh food compartment temperature in degrees F.

6.2.2 Refrigerators and refrigerator-freezers. The average per-cycle energy consumption for a cycle type is expressed in kilowatt-hours per-cycle to the nearest one hundredth (0.01) kilowatt-hour and shall be defined in the applicable following manner.

6.2.2.1 If the fresh food compartment temperature is always at or below 45 °F. (7.2 °C.) in both of the tests and the freezer compartment temperature is always at or below 15 °F. (−9.4 °C.) in both tests of a refrigerator or at or below 5 °F. (−15 °C.) in both tests of a refrigerator-freezer, the per-cycle energy consumption shall be:

E=ET1

where

E is defined in 6.2.1.1,

ET is defined in 5.2.1, and

Number 1 indicates the test period during which the highest freezer compartment temperature was measured.

6.2.2.2 If the conditions of 6.2.2.1 do not exist, the per-cycle energy consumption shall be defined by the higher of the two values calculated by the following two formulas:

$E = ET1 + ((ET2 - ET1) \times (45.0 - TR1)/(TR2 - TR1))$

and

$E = ET1 + ((ET2 - ET1) \times (k - TF1)/(TF2 - TF1))$

Where:

E is defined in 6.2.1.1;

ET is defined in 5.2.1;

TR and numbers 1 and 2 are defined in 6.2.1.2;

TF = Freezer compartment temperature determined according to 5.1.4 in degrees F;

45.0 is a specified fresh food compartment temperature in degrees F; and

k is a constant 15.0 for refrigerators or 5.0 for refrigerator-freezers each being standardized freezer compartment temperature in degrees F.

6.2.3 Variable Anti-Sweat Heater Models. The standard cycle energy consumption of an electric refrigerator-freezer with a variable anti-sweat heater control (E_{std}), expressed in kilowatt-hours per day, shall be calculated equivalent to:

E_{std} = E + (Correction Factor) where E is determined by 6.2.1.1, 6.2.1.2, 6.2.2.1, or 6.2.2.2, whichever is appropriate, with the anti-sweat heater switch in the ''off'' position or, for products without anti-sweat heater switches, the anti-sweat heater in its lowest energy use state.

Correction Factor = (Anti-sweat Heater Power × System-loss Factor) × (24 hrs/1 day) × (1 kW/1000 W)

Where:

Anti-sweat Heater Power = 0.034 * (Heater Watts at 5%RH)
+ 0.211 * (Heater Watts at 15%RH)
+ 0.204 * (Heater Watts at 25%RH)
+ 0.166 * (Heater Watts at 35%RH)
+ 0.126 * (Heater Watts at 45%RH)
+ 0.119 * (Heater Watts at 55%RH)
+ 0.069 * (Heater Watts at 65%RH)
+ 0.047 * (Heater Watts at 75%RH)
+ 0.008 * (Heater Watts at 85%RH)
+ 0.015 * (Heater Watts at 95%RH)

Heater Watts at a specific relative humidity = the nominal watts used by all heaters at that specific relative humidity, 72 °F (22.2 °C) ambient, and DOE reference temperatures of fresh food (FF) average temperature of 45 °F (7.2 °C) and freezer (FZ) average temperature of 5 °F (−15 °C).

System-loss Factor = 1.3

6.3 Externally vented refrigerator or refrigerator-freezers. Per-cycle energy consumption measurements for the externally vented refrigerator or refrigerator-freezer shall be calculated in accordance with the requirements of this appendix, as modified in sections 6.3.1–6.3.7.

6.3.1 Correction factor. A correction factor, K, shall be calculated as:

$K = ec_{90}/ec_{80}$

where ec_{90} and ec_{80} = the energy consumption test results as determined under 5.4.2.1.

6.3.2 Combining test results of different settings of compartment temperature controls. For a given setting of the anti-sweat heater, follow the calculation procedures of 6.2 to combine the test results for energy consumption of the unit at different temperature control settings for each condenser inlet air temperature tested under 5.4.2.2, 5.4.2.3, and 5.4.2.4, where applicable, $(e_{90})_i$, $(e_{60})_i$, $(e_{50})_i$, and $(e_{30})_i$. The combined values are ε_{90}, ε_{60}, ε_{50}, and ε_{30}, where applicable, in kWh/day.

6.3.3 Energy consumption corrections. For a given setting of the anti-sweat heater, the energy consumptions ε_{90}, ε_{60}, ε_{50}, and ε_{30} calculated in 6.3.2 shall be adjusted by multiplying the correction factor K to obtain the corrected energy consumptions per day, in kWh/day:

$E_{90} = K \times \varepsilon_{90}$,
$E_{60} = K \times \varepsilon_{60}$
$E_{50} = K \times \varepsilon_{50}$, and
$E_{30} = K \times \varepsilon_{30}$

where,

K is determined under section 6.3.1, and ε_{90}, ε_{60}, ε_{50}, and ε_{30} are determined under section 6.3.2.

6.3.4 Energy profile equation. For a given setting of the anti-sweat heater, the energy consumption E_X, in kWh/day, at a specific exterior air temperature between 80 °F (26.7 °C) and 60 °F (26.7 °C) shall be calculated by the following equation:

$E_X = a + bT_X$,

where,

T_X = exterior air temperature in °F;
$a = 3E_{60} - 2E_{90}$, in kWh/day;
$b = (E_{90} - E_{60})/30$, in kWh/day per °F.

6.3.5 Energy consumption at 80 °F (26.7 °C), 75 °F (23.9 °C) and 65 °F (18.3 °C). For a given setting of the anti-sweat heater, calculate the energy consumptions at 80 °F (26.7 °C), 75 °F (23.9 °C) and 65 °F (18.3 °C) exterior air temperatures, E_{80}, E_{75} and E_{65}, respectively, in kWh/day, using the equation in 6.3.4.

6.3.6 National average per cycle energy consumption. For a given setting of the anti-sweat heater, calculate the national average energy consumption, E_N, in kWh/day, using one of the following equations:

$E_N = 0.523 \times E_{60} + 0.165 \times E_{65} + 0.181 \times E_{75} + 0.131 \times E_{80}$, for units not tested under 5.4.2.4,

$E_N = 0.257 \times E_{30} + 0.266 \times E_{50} + 0.165 \times E_{65} + 0.181 \times E_{75} + 0.131 \times E_{80}$, for units tested under 5.4.2.4,

where,

E_{30}, E_{50}, and E_{60} are defined in 6.3.3,

E_{65}, E_{75}, and E_{80} are defined in 6.3.5, and

the coefficients are weather associated weighting factors.

6.3.7 Regional average per cycle energy consumption. If regional average per cycle energy consumption is required to be calculated, for a given setting of the anti-sweat heater, calculate the regional average per cycle energy consumption, E_R, in kWh/day, for the regions in figure 1 using one of the following equations and the coefficients in the table A:

$E_R = a_1 \times E_{60} + c \times E_{65} + d \times E_{75} + e \times E_{80}$, for a unit that is not required to be tested under 5.4.2.4,

$E_R = a \times E_{30} + b \times E_{50} + c \times E_{65} + d \times E_{75} + e \times E_{80}$, for a unit tested under 5.4.2.4,

where:

E_{30}, E_{50}, and E_{60} are defined in 6.3.3,

E_{65}, E_{75}, and E_{80} are defined in 6.3.5, and

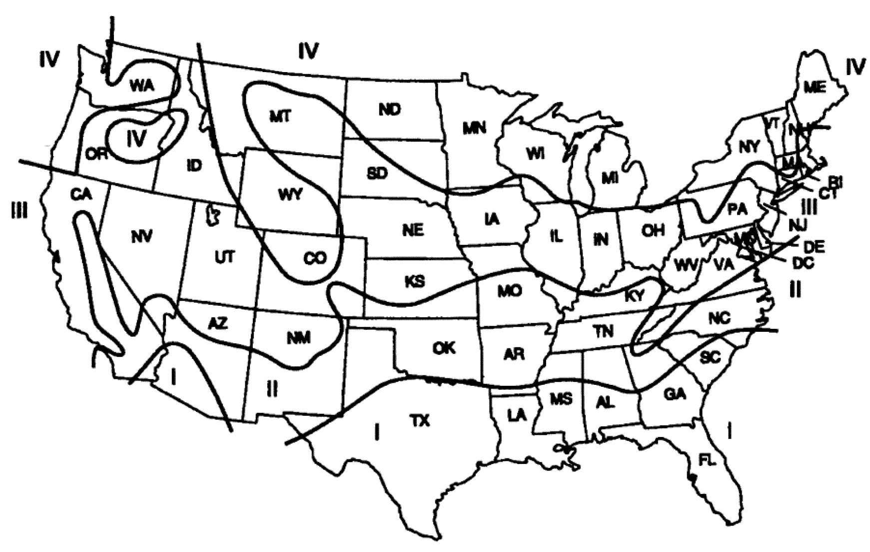
a_1, a, b, c, d, e are weather associated weighting factors for the Regions, as specified in Table A:

TABLE A—COEFFICIENTS FOR CALCULATING REGIONAL AVERAGE PER CYCLE ENERGY CONSUMPTION

[Weighting Factors]

Regions	a_1	a	b	c	d	e
I	0.282	0.039	0.244	0.194	0.326	0.198
II	0.486	0.194	0.293	0.191	0.193	0.129
III	0.584	0.302	0.282	0.178	0.159	0.079
IV	0.664	0.420	0.244	0.161	0.121	0.055

Figure 2: Weather Regions for the United States



Alaska: Region IV

Hawaii: Region I

7. Test Procedure Waivers

To the extent that the procedures contained in this appendix do not provide a means for determining the energy consumption of a refrigerator or refrigerator-freezer, a manufacturer must obtain a waiver under 10 CFR 430.27 to establish an acceptable test procedure for each such product. Such instances could, for example, include situations where the test set-up for a particular refrigerator or refrigerator-freezer basic model is not clearly defined by the provisions of section 2. For details regarding the criteria and procedures for obtaining a waiver, please refer to 10 CFR 430.27.

[47 FR 34526, Aug. 10, 1982; 48 FR 13013, Mar. 29, 1983, as amended at 54 FR 36240, Aug. 31, 1989; 54 FR 38788, Sept. 20, 1989; 62 FR 47539, 47540, Sept. 9, 1997; 68 FR 10960, Mar. 7, 2003; 75 FR 78860, Dec. 16, 2010; 76 FR 12502, Mar. 7, 2011; 76 FR 24781, May 2, 2011]

APPENDIX B TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FREEZERS

The provisions of appendix B shall apply to all products manufactured on or after the effective date of any amended standards promulgated by DOE pursuant to Section 325(b)(4) of the Energy Policy and Conservation Act of 1975, as amended by the Energy Independence and Security Act of 2007 (to be codified at 42 U.S.C. 6295(b)(4)).

1. Definitions

Section 3, *Definitions*, of HRF–1–2008 (incorporated by reference; see §430.3) applies to this test procedure.

1.1 ''Adjusted total volume'' means the product of the freezer volume as defined in HRF–1–2008 (incorporated by reference; see §430.3) in cubic feet multiplied by an adjustment factor.

1.2 ''Anti-sweat heater'' means a device incorporated into the design of a freezer to prevent the accumulation of moisture on exterior or interior surfaces of the cabinet.

1.3 ''Anti-sweat heater switch'' means a user-controllable switch or user interface which modifies the activation or control of anti-sweat heaters.

1.4 ''Automatic defrost'' means a system in which the defrost cycle is automatically initiated and terminated, with resumption of normal refrigeration at the conclusion of defrost operation. The system automatically prevents the permanent formation of frost on all refrigerated surfaces. Nominal refrigerated food temperatures are maintained during the operation of the automatic defrost system.

1.5 ''Automatic icemaker'' means a device that can be supplied with water without user intervention, either from a pressurized water supply system or by transfer from a water reservoir, that automatically produces, harvests, and stores ice in a storage bin, with means to automatically interrupt the harvesting operation when the ice storage bin is filled to a pre-determined level.

1.6 ''Cycle'' means the period of 24 hours for which the energy use of a freezer is calculated as though the consumer-activated compartment temperature controls were set to maintain the standardized temperature (see section 3.2).

1.7 ''Cycle type'' means the set of test conditions having the calculated effect of operating a freezer for a period of 24 hours with the consumer-activated controls other than the compartment temperature control set to establish various operating characteristics.

1.8 ''HRF–1–2008'' means AHAM Standard HRF–1–2008, Association of Home Appliance Manufacturers, Energy and Internal Volume of Refrigerating Appliances (2008), including Errata to Energy and Internal Volume of Refrigerating Appliances, Correction Sheet issued November 17, 2009. Only sections of HRF–1–2008 (incorporated by reference; see §430.3) specifically referenced in this test procedure are part of this test procedure. In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over HRF–1–2008.

1.9 ''Long-time automatic defrost'' means an automatic defrost system where successive defrost cycles are separated by 14 hours or more of compressor operating time.

1.10 ''Quick freeze'' means an optional feature on freezers that is initiated manually. It bypasses the thermostat control and operates continually until the feature is terminated either manually or automatically.

1.11 ''Separate auxiliary compartment'' means a freezer compartment other than the first freezer compartment of a freezer having more than one compartment. Access to a separate auxiliary compartment is through a separate exterior door or doors rather than through the door or doors of another compartment. Separate auxiliary freezer compartments may not be larger than the first freezer compartment.

1.12 ''Special compartment'' means any compartment without doors directly accessible from the exterior, and with separate temperature control that is not convertible from fresh food temperature range to freezer temperature range.

1.13 ''Stabilization period'' means the total period of time during which steady-state conditions are being attained or evaluated.

1.14 ''Standard cycle'' means the cycle type in which the anti-sweat heater switch, when provided, is set in the highest energy-consuming position.

1.15 ''Variable defrost control'' means an automatic defrost system in which successive defrost cycles are determined by an operating condition variable or variables other than solely compressor operating time. This includes any electrical or mechanical device performing this function. A control scheme that changes the defrost interval from a fixed length to an extended length (without any intermediate steps) is not considered a variable defrost control. A variable defrost control feature should predict the accumulation of frost on the evaporator and react accordingly. Therefore, the times between defrost should vary with different usage patterns and include a continuum of lengths of time between defrosts as inputs vary.

2. Test Conditions

2.1 Ambient Temperature. The ambient temperature shall be 90.0 ± 1.0 °F (32.2 ± 0.6 °C) during the stabilization period and the test period.

2.2 Operational Conditions. The freezer shall be installed and its operating conditions maintained in accordance with HRF–1–2008, (incorporated by reference; see § 430.3), sections 5.3 through section 5.5.5.5 (but excluding sections 5.5.5.2 and 5.5.5.4). The quick freeze option shall be switched off except as specified in section 3.1. Additional clarifications are noted in sections 2.3 through 2.6.

2.3 Anti-Sweat Heaters. The anti-sweat heater switch is to be on during one test and off during a second test. In the case of an electric freezer with variable anti-sweat heater control, the standard cycle energy use shall be the result of the calculation described in 6.2.2.

2.4 The cabinet and its refrigerating mechanism shall be assembled and set up in accordance with the printed consumer instructions supplied with the cabinet. Set-up of the freezer shall not deviate from these instructions, unless explicitly required or allowed by this test procedure. Specific required or allowed deviations from such set-up include the following:

(a) Connection of water lines and installation of water filters are not required;

(b) Clearance requirements from surfaces of the product shall be as described in section 2.6 below;

(c) The electric power supply shall be as described in HRF–1–2008 (incorporated by reference; see § 430.3) section 5.5.1;

(d) Temperature control settings for testing shall be as described in section 3 of this appendix. Settings for special compartments shall be as described in section 2.5 of this appendix;

(e) The product does not need to be anchored or otherwise secured to prevent tipping during energy testing;

(f) All the product's chutes and throats required for the delivery of ice shall be free of packing, covers, or other blockages that may be fitted for shipping or when the icemaker is not in use; and

(g) Ice storage bins shall be emptied of ice.

For cases in which set-up is not clearly defined by this test procedure, manufacturers must submit a petition for a waiver (see section 7).

2.5 Special compartments shall be tested with controls set to provide the coldest temperature. However, for special compartments in which temperature control is achieved using the addition of heat (including resistive electric heating, refrigeration system waste heat, or heat from any other source, but excluding the transfer of air from another part of the interior of the product) for any part of the controllable temperature range of that compartment, the product energy use shall be determined by averaging two sets of tests. The first set of tests shall be conducted with such special compartments at their coldest settings, and the second set of tests shall be conducted with such special compartments at their warmest settings. The requirements for the warmest or coldest temperature settings of this section do not apply to features or functions associated with temperature control (such as quick freeze) that are initiated manually and terminated automatically within 168 hours.

2.6 The space between the back of the cabinet and a vertical surface (the test room wall or simulated wall) shall be the minimum distance in accordance with the manufacturer's instructions. However, the clearance shall not be greater than 2 inches (51 mm) from the plane of the cabinet's back panel to the vertical surface. If permanent rear spacers extend further than this distance, the appliance shall be located with the spacers in contact with the vertical surface.

2.7 Steady State Condition. Steady-state conditions exist if the temperature measurements taken at 4-minute intervals or less during a stabilization period are not changing at a rate greater than 0.042 °F (0.023 °C) per hour as determined by the applicable condition of A or B described below.

A—The average of the measurements during a 2-hour period if no cycling occurs or during a number of complete repetitive compressor cycles occurring through a period of no less than 2 hours is compared to the average over an equivalent time period with 3 hours elapsing between the two measurement periods.

B—If A above cannot be used, the average of the measurements during a number of complete repetitive compressor cycles occurring through a period of no less than 2 hours and including the last complete cycle before a defrost period (or if no cycling occurs, the average of the measurements during the last 2 hours before a defrost period) are compared to the same averaging period before the following defrost period.

3. Test Control Settings

3.1 Model with No User Operable Temperature Control. A test shall be performed during which the compartment temperature and energy use shall be measured. A second test shall be performed with the temperature control electrically short circuited to cause the compressor to run continuously. If the model has the quick freeze option, this option must be used to bypass the temperature control.

3.2 Model with User Operable Temperature Control. Testing shall be performed in accordance with one of the following sections using the standardized temperature of 0.0 °F (−17.8 °C).

For the purposes of comparing compartment temperatures with standardized temperatures, as described in sections 3.2.1 and 3.2.2, the freezer compartment temperature shall be as specified in section 5.1.3.

3.2.1 A first test shall be performed with all temperature controls set at their median position midway between their warmest and coldest settings. For mechanical control systems, knob detents shall be mechanically defeated if necessary to attain a median setting. For electronic control systems, the test shall be performed with all compartment temperature controls set at the average of the coldest and warmest settings—if there is no setting equal to this average, the setting closest to the average shall be used. If there are two such settings equally close to the average, the higher of these temperature control settings shall be used. A second test shall be performed with all controls set at either their warmest or their coldest setting (not electrically or mechanically bypassed), whichever is appropriate, to attempt to achieve compartment temperatures measured during the two tests which bound (*i.e.*, one is above and one is below) the standardized temperature. If the compartment temperatures measured during these two tests bound the standardized temperature, then these test results shall be used to determine energy consumption. If the compartment temperature measured with all controls set at their coldest setting is above the standardized temperature, the tested unit fails the test and cannot be rated. If the compartment temperature measured with all controls set at their warmest setting is below the standardized temperature, then the result of this test alone will be used to determine energy consumption. Also see Table 1 below, which summarizes these requirements.

TABLE 1—TEMPERATURE SETTINGS FOR FREEZERS

First test		Second test		Energy calculation based on:
Settings	Results	Settings	Results	
Mid	Low	Warm ..	Low	Second Test Only.
	....	....	High	First and Second Tests.
	High	Cold	Low	First and Second Tests.
	....	....	High	No Energy Use Rating.

3.2.2 Alternatively, a first test may be performed with all temperature controls set at their warmest setting. If the compartment temperature is below the standardized temperature, then the result of this test alone will be used to determine energy consumption. If this condition is not met, then the unit shall be tested in accordance with section 3.2.1.

4. Test Period

Tests shall be performed by establishing the conditions set forth in section 2 and using the control settings as set forth in section 3 above.

4.1 Nonautomatic Defrost. If the model being tested has no automatic defrost system, the test time period shall start after steady-state conditions have been achieved and be no less than 3 hours in duration. During the test period, the compressor motor shall complete two or more whole compressor cycles. (A compressor cycle is a complete ''on'' and a complete ''off'' period of the motor.) If no ''off'' cycling will occur, as determined during the stabilization period, the test period shall be 3 hours. If incomplete cycling occurs (less than two compressor cycles during a 24-hour period), the results of the 24-hour period shall be used.

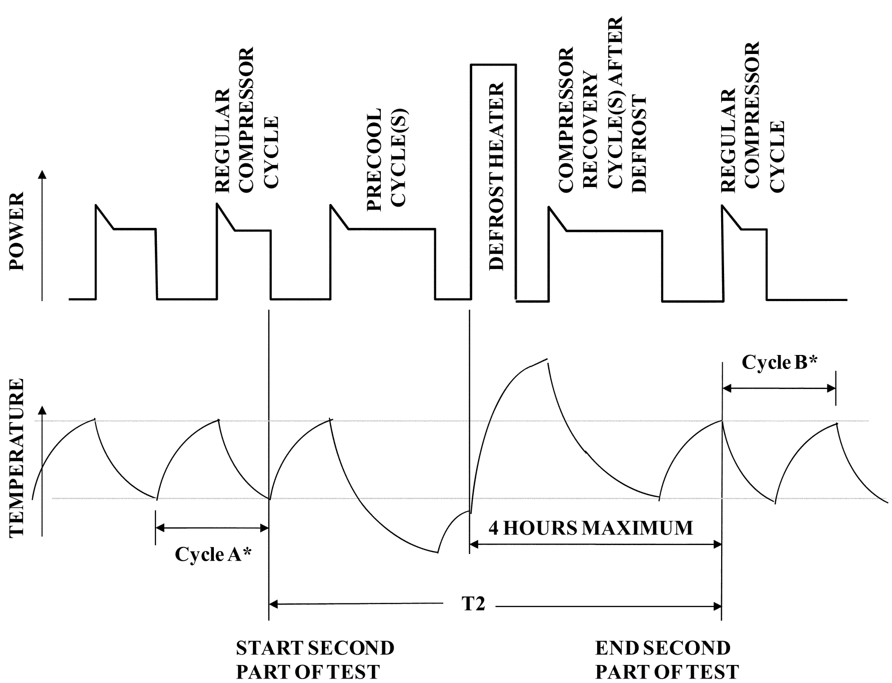
4.2 Automatic Defrost. If the model being tested has an automatic defrost system, the test time period shall start after steady-state conditions have been achieved and be from one point during a defrost period to the same point during the next defrost period. If the model being tested has a long-time automatic defrost system, the alternate provisions of 4.2.1 may be used. If the model being tested has a variable defrost control, the provisions of 4.2.2 shall apply.

4.2.1 Long-time Automatic Defrost. If the model being tested has a long-time automatic defrost system, the two-part test described in this section may be used. The first part is a stable period of compressor operation that includes no portions of the defrost cycle, such as precooling or recovery, that is otherwise the same as the test for a unit having no defrost provisions (section 4.1). The second part is designed to capture the energy consumed during all of the events occurring with the defrost control sequence that are outside of stable operation.

4.2.1.1 Cycling Compressor System. For a system with a cycling compressor, the second part starts at the termination of the last regular compressor ''on'' cycle. The average temperature of the compartment measured from the termination of the previous compressor ''on'' cycle to the termination of the last regular compressor ''on'' cycle must be within 0.5 °F (0.3 °C) of the average temperature of the compartment measured for the first part of the test. If any compressor cycles occur prior to the defrost heater being energized that cause the average temperature in the compartment to deviate from the first part temperature by more than 0.5 °F (0.3 °C), these compressor cycles are not considered regular compressor cycles and must be included in the second part of the test. As an example, a ''precool'' cycle, which is an extended compressor cycle that lowers the compartment temperature prior to energizing the defrost heater, must be included in the second part of the test. The test period for the second part of the test ends at the initiation of the first regular compressor cycle after the compartment temperatures have fully recovered to their stable conditions. The average temperature of the compartment measured from this initiation of the first regular compressor ''on'' cycle until the initiation of the next regular compressor ''on'' cycle must be within 0.5 °F (0.3 °C) of the average temperature of the compartment measured for the first part of the test. The second part of the test may be terminated after 4 hours if the above conditions cannot be met. See Figure 1.

Figure 1

Long-time Automatic Defrost Diagram for Cycling Compressors

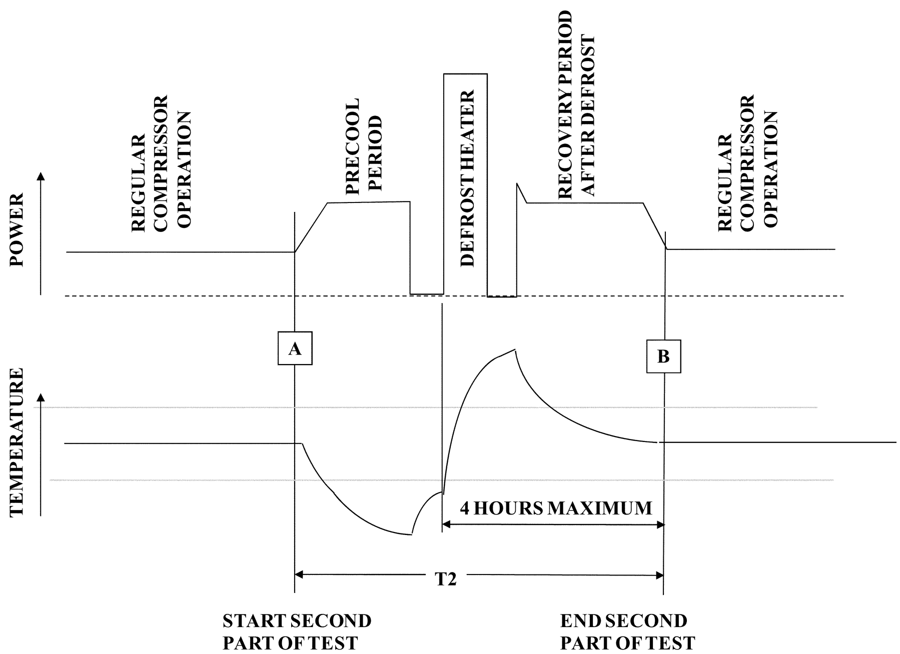


*Average compartment temperature during cycles A & B must be within 0.5 ˚F of the average temperature for the first part of the test. This requirement does not apply for cycle B if the 4 hour limit is reached.

4.2.1.2 Non-cycling Compressor System. For a system with a non-cycling compressor, the second part starts at a time before defrost during stable operation when the compartment temperature is within 0.5 °F (0.3 °C) of the average temperature of the compartment measured for the first part of the test. The second part stops at a time after defrost during stable operation when the compartment temperature is within 0.5 °F (0.3 °C) of the average temperature of the compartment measured for the first part of the test. The second part of the test may be terminated after 4 hours if the above conditions cannot be met. See Figure 2.

Figure 2

Long-time Automatic Defrost Diagram for Non-cycling Compressors



***Average compartment temperature at times A & B must be within 0.5 ˚F of the average temperature for the first part of the test. This requirement does not apply for time B if the 4 hour limit is reached.**

4.2.2 Variable Defrost Control. If the model being tested has a variable defrost control system, the test shall consist of the same two parts as the test for long-time automatic defrost (section 4.2.1).

5. Test Measurements

5.1 Temperature Measurements. Temperature measurements shall be made at the locations prescribed in Figure 5–2 of HRF–1–2008 (incorporated by reference; *see* §430.3) and shall be accurate to within ± 0.5 °F (0.3 °C).

If the interior arrangements of the cabinet do not conform with those shown in Figure 5.2 of HRF–1–2008, the product may be tested by relocating the temperature sensors from the locations specified in the figures to avoid interference with hardware or components within the cabinet, in which case the specific locations used for the temperature sensors shall be noted in the test data records maintained by the manufacturer in accordance with 10 CFR 429.14, and the certification report shall indicate that non-standard sensor locations were used.

5.1.1 Measured Temperature. The measured temperature is to be the average of all sensor temperature readings taken at a particular point in time. Measurements shall be taken at regular intervals not to exceed 4 minutes.

5.1.2 Compartment Temperature. The compartment temperature for each test period shall be an average of the measured temperatures taken during the test period as defined in section 4. For long-time automatic defrost models, compartment temperature shall be that measured in the first part of the test period specified in section 4.2.1. For models with variable defrost controls, compartment temperatures shall be those measured in the first part of the test period specified in section 4.2.2.

5.1.3 Freezer Compartment Temperature. The freezer compartment temperature shall be calculated as:

$$TF = \frac{\sum_{i=1}^{F}(TF_i) \times (VF_i)}{\sum_{i=1}^{F}(VF_i)}$$

Where:

F is the total number of applicable freezer compartments, which include the first freezer compartment and any number of separate auxiliary freezer compartments;

TF_i is the compartment temperature of freezer compartment "i" determined in accordance with section 5.1.2; and

VF_i is the volume of freezer compartment "i".

5.2 Energy Measurements:

5.2.1 Per-Day Energy Consumption. The energy consumption in kilowatt-hours per day for each test period shall be the energy expended during the test period as specified in section 4 adjusted to a 24-hour period. The adjustment shall be determined as follows:

5.2.1.1 Nonautomatic and Automatic Defrost Models. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (EP \times 1440 \times K)/T$

Where:

ET = test cycle energy expended in kilowatt-hours per day;

EP = energy expended in kilowatt-hours during the test period;

T = length of time of the test period in minutes;

1440 = conversion factor to adjust to a 24-hour period in minutes per day; and

K = dimensionless correction factor of 0.7 for chest freezers and 0.85 for upright freezers to adjust for average household usage.

5.2.1.2 Long-time Automatic Defrost. If the two-part test method is used, the energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (1440 \times K \times EP1/T1) + (EP2 - (EP1 \times T2/T1)) \times K \times (12/CT)$

Where:

ET, 1440, and K are defined in section 5.2.1.1;

EP1 = energy expended in kilowatt-hours during the first part of the test;

EP2 = energy expended in kilowatt-hours during the second part of the test;

CT = defrost timer run time or compressor run time between defrosts in hours required to cause it to go through a complete cycle, rounded to the nearest tenth of an hour;

12 = conversion factor to adjust for a 50 percent run time of the compressor in hours per day; and

T1 and T2 = length of time in minutes of the first and second test parts respectively.

5.2.1.3 Variable Defrost Control. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

$ET = (1440 \times K \times EP1/T1) + (EP2 - (EP1 \times T2/T1)) \times K \times (12/CT)$,

Where:

ET, K, and 1440 are defined in section 5.2.1.1;

EP1, EP2, T1, T2, and 12 are defined in section 5.2.1.2;

$CT = (CT_L \times CT_M)/(F \times (CT_M - CT_L) + CT_L)$

Where:

CT_L = least or shortest compressor run time between defrosts in hours rounded to the nearest tenth of an hour (greater than or equal to 6 hours but less than or equal to 12 hours);

CT_M = maximum compressor run time between defrosts in hours rounded to the nearest tenth of an hour (greater than CT_L but not more than 96 hours);

F = ratio of per day energy consumption in excess of the least energy and the maximum difference in per-day energy consumption and is equal to 0.20.

For variable defrost models with no values for CT_L and CT_M in the algorithm, the default values of 12 and 84 shall be used, respectively.

5.3 Volume Measurements. The total refrigerated volume, VT, shall be measured in accordance with HRF–1–2008, (incorporated by reference; see §430.3), section 3.30 and sections 4.2 through 4.3.

In the case of freezers with automatic icemakers, the volume occupied by the automatic icemaker, including its ice storage bin, is to be included in the volume measurement.

6. Calculation of Derived Results From Test Measurements

6.1 Adjusted Total Volume. The adjusted total volume, VA, for freezers under test shall be defined as:

$VA = VT \times CF$

Where:

VA = adjusted total volume in cubic feet;
VT = total refrigerated volume in cubic feet; and
CF = dimensionless correction factor of 1.76.

6.2 Average Per-Cycle Energy Consumption

6.2.1 The average per-cycle energy consumption for a cycle type is expressed in kilowatt-hours per cycle to the nearest one hundredth (0.01) kilowatt-hour and shall depend on the compartment temperature attainable as shown below.

6.2.1.1 If the compartment temperature is always below 0.0 °F (−17.8 °C), the average per-cycle energy consumption shall be equivalent to:

$E = ET1 + IET$

Where:

E = total per-cycle energy consumption in kilowatt-hours per day;
ET is defined in 5.2.1;
The number 1 indicates the test period during which the highest compartment temperature is measured; and
IET, expressed in kilowatt-hours per cycle, equals 0.23 for a product with an automatic icemaker and otherwise equals 0 (zero).

6.2.1.2 If one of the compartment temperatures measured for a test period is greater than 0.0 °F (17.8 °C), the average per-cycle energy consumption shall be equivalent to:

$E = ET1 + ((ET2 - ET1) \times (0.0 - TF1)/(TF2 - TF1)) + IET$

Where:

E and IET are defined in 6.2.1.1 and ET is defined in 5.2.1;
TF = freezer compartment temperature determined according to 5.1.3 in degrees F;
The numbers 1 and 2 indicate measurements taken during the first and second test period as appropriate; and
0.0 = standardized compartment temperature in degrees F.

6.2.2 Variable Anti-Sweat Heater Models. The standard cycle energy consumption of an electric freezer with a variable anti-sweat heater control (E_{std}), expressed in kilowatt-hours per day, shall be calculated equivalent to:

E_{std} = E + (Correction Factor) where E is determined by 6.2.1.1, or 6.2.1.2, whichever is appropriate, with the anti-sweat heater switch in the ''off'' position or, for a product without an anti-sweat heater switch, the anti-sweat heater in its lowest energy use state.
Correction Factor = (Anti-sweat Heater Power × System-loss Factor) × (24 hrs/1 day) × (1 kW/1000 W)

Where:

Anti-sweat Heater Power = 0.034 * (Heater Watts at 5%RH)
+ 0.211 * (Heater Watts at 15%RH)
+ 0.204 * (Heater Watts at 25%RH)
+ 0.166 * (Heater Watts at 35%RH)
+ 0.126 * (Heater Watts at 45%RH)
+ 0.119 * (Heater Watts at 55%RH)
+ 0.069 * (Heater Watts at 65%RH)
+ 0.047 * (Heater Watts at 75%RH)
+ 0.008 * (Heater Watts at 85%RH)
+ 0.015 * (Heater Watts at 95%RH)
Heater Watts at a specific relative humidity = the nominal watts used by all heaters at that specific relative humidity, 72 °F ambient (22.2 °C), and DOE reference freezer (FZ) average temperature of 0 °F (−17.8 °C).
System-loss Factor = 1.3

7. Test Procedure Waivers

To the extent that the procedures contained in this appendix do not provide a means for determining the energy consumption of a freezer, a manufacturer must obtain a waiver under 10 CFR 430.27 to establish an acceptable test procedure for each such product. Such instances could, for example, include situations where the test set-up for a particular freezer basic model is not clearly defined by the provisions of section 2. For details regarding the criteria and procedures for obtaining a waiver, please refer to 10 CFR 430.27.

[75 FR 78866, Dec. 16, 2010, as amended at 76 FR 12502, Mar. 7, 2011; 76 FR 24781, May 2, 2011]

APPENDIX B1 TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FREEZERS

The provisions of appendix B1 shall apply to all products manufactured prior to the effective date of any amended standards promulgated by DOE pursuant to Section 325(b)(4) of the Energy Policy and Conservation Act of 1975, as amended by the Energy Independence and Security Act of 2007 (to be codified at 42 U.S.C. 6295(b)(4)).

1. Definitions

Section 3, *Definitions*, of HRF–1–1979 (incorporated by reference; see § 430.3) applies to this test procedure.

1.1 Adjusted total volume'' means the product of, (1) the freezer volume as defined in HRF–1–1979 in cubic feet, times (2) an adjustment factor.

1.2 ''Anti-sweat heater'' means a device incorporated into the design of a freezer to prevent the accumulation of moisture on exterior or interior surfaces of the cabinet.

1.3 ''Anti-sweat heater switch'' means a user-controllable switch or user interface which modifies the activation or control of anti-sweat heaters.

1.4 ''Automatic Defrost'' means a system in which the defrost cycle is automatically initiated and terminated, with resumption of normal refrigeration at the conclusion of defrost operation. The system automatically prevents the permanent formation of frost on all refrigerated surfaces. Nominal refrigerated food temperatures are maintained during the operation of the automatic defrost system.

1.5 ''Cycle'' means the period of 24 hours for which the energy use of a freezer is calculated as though the consumer-activated compartment temperature controls were set to maintain the standardized temperature (see section 3.2).

1.6 ''Cycle type'' means the set of test conditions having the calculated effect of operating a freezer for a period of 24 hours with the consumer-activated controls other than the compartment temperature control set to establish various operating characteristics.

1.7 ''HRF–1–1979'' means the Association of Home Appliance Manufacturers standard for household refrigerators, combination refrigerator-freezers, and household freezers, also approved as an American National Standard as a revision of ANSI B 38.1–1970. Only sections of HRF–1–1979 (incorporated by reference; see § 430.3) specifically referenced in this test procedure are part of this test procedure. In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over HRF–1–1979.

1.8 ''Long-time Automatic Defrost'' means an automatic defrost system where successive defrost cycles are separated by 14 hours or more of compressor-operating time.

1.9 ''Quick freeze'' means an optional feature on freezers that is initiated manually. It bypasses the thermostat control and operates continually until the feature is terminated either manually or automatically.

1.10 ''Separate auxiliary compartment'' means a freezer compartment other than the first freezer compartment of a freezer having more than one compartment. Access to a separate auxiliary compartment is through a separate exterior door or doors rather than through the door or doors of another compartment. Separate auxiliary freezer compartments may not be larger than the first freezer compartment.

1.11 ''Special compartment'' means any compartment without doors directly accessible from the exterior, and with separate temperature control that is not convertible from fresh food temperature range to freezer temperature range.

1.12 ''Stabilization Period'' means the total period of time during which steady-state conditions are being attained or evaluated.

1.13 ''Standard cycle'' means the cycle type in which the anti-sweat heater switch, when provided, is set in the highest energy consuming position.

1.14 ''Variable defrost control'' means an automatic defrost system in which successive defrost cycles are determined by an operating condition variable or variables other than solely compressor operating time. This includes any electrical or mechanical device performing this function. A control scheme that changes the defrost interval from a fixed length to an extended length (without any intermediate steps) is not considered a variable defrost control. A variable defrost control feature should predict the accumulation of frost on the evaporator and react accordingly. Therefore, the times between defrost should vary with different usage patterns and include a continuum of lengths of time between defrosts as inputs vary.

2. Test Conditions.

2.1 Ambient Temperature. The ambient temperature shall be 90.0 ± 1.0 °F (32.2 ± 0.6 °C) during the stabilization period and the test period.

2.2 Operational Conditions. The freezer shall be installed and its operating conditions maintained in accordance with HRF–1–1979, (incorporated by reference; see § 430.3), section 7.2 through section 7.4.3.3 (but excluding section 7.4.3.2), except that the vertical ambient gradient at locations 10 inches (25.4 cm) out from the centers of the two sides of the unit being tested is to be maintained during the test. Unless the area is obstructed by shields or baffles, the gradient is to be maintained from 2 inches (5.1 cm) above the floor or supporting platform to a height 1 foot (30.5 cm) above the unit under test. Defrost controls are to be operative. The quick freeze option shall be switched off except as specified in section 3.1. Additional clarifications are noted in sections 2.3 through 2.6.

2.3 Anti-Sweat Heaters. The anti-sweat heater switch is to be on during one test and off during a second test. In the case of an electric freezer equipped with variable anti-sweat heater control, the standard cycle energy use shall be the result of the calculation described in 6.2.2.

2.4 The cabinet and its refrigerating mechanism shall be assembled and set up in accordance with the printed consumer instructions supplied with the cabinet. Set-up of the freezer shall not deviate from these instructions, unless explicitly required or allowed by this test procedure. Specific required or allowed deviations from such set-up include the following:

(a) Connection of water lines and installation of water filters are not required;

(b) Clearance requirements from surfaces of the product shall be as specified in section 2.6 below;

(c) The electric power supply shall be as described in HRF–1–1979 (incorporated by reference; see §430.3) section 7.4.1;

(d) Temperature control settings for testing shall be as described in section 3 of this appendix. Settings for special compartments shall be as described in section 2.5 of this appendix;

(e) The product does not need to be anchored or otherwise secured to prevent tipping during energy testing; and

(f) All the product's chutes and throats required for the delivery of ice shall be free of packing, covers, or other blockages that may be fitted for shipping or when the icemaker is not in use.

For cases in which set-up is not clearly defined by this test procedure, manufacturers must submit a petition for a waiver (see section 7).

2.5 Special compartments shall be tested with controls set to provide the coldest temperature. This requirement for the coldest temperature does not apply to features or functions (such as quick freeze) that are initiated manually and terminated automatically within 168 hours.

2.6 The space between the back of the cabinet and a vertical surface (the test room wall or simulated wall) shall be the minimum distance in accordance with the manufacturer's instructions.

2.7 Steady State Condition. Steady state conditions exist if the temperature measurements taken at four minute intervals or less during a stabilization period are not changing at a rate greater than 0.042 °F. (0.023 °C.) per hour as determined by the applicable condition of A or B.

A—The average of the measurements during a two hour period if no cycling occurs or during a number of complete repetitive compressor cycles through a period of no less than two hours is compared to the average over an equivalent time period with three hours elapsed between the two measurement periods.

B—If A above cannot be used, the average of the measurements during a number of complete repetitive compressor cycles through a period of no less than two hours and including the last complete cycle prior to a defrost period, or if no cycling occurs, the average of the measurements during the last two hours prior to a defrost period; are compared to the same averaging period prior to the following defrost period.

3. Test Control Settings.

3.1 Model with No User Operable Temperature Control. A test shall be performed during which the compartment temperature and energy use shall be measured. A second test shall be performed with the temperature control electrically short circuited to cause the compressor to run continuously. If the model has the quick freeze option, this option must be used to bypass the temperature control.

3.2 Model with User Operable Temperature Control. Testing shall be performed in accordance with one of the following sections using the standardized temperature of 0.0 °F (−17.8 °C).

For the purposes of comparing compartment temperatures with standardized temperatures, as described in sections 3.2.1 through 3.2.3, the freezer compartment temperature shall be as specified in section 5.1.3.

3.2.1 A first test shall be performed with all temperature controls set at their median position midway between their warmest and coldest settings. For mechanical control systems, knob detents shall be mechanically defeated if necessary to attain a median setting. For electronic control systems, the test shall be performed with all compartment temperature controls set at the average of the coldest and warmest settings—if there is no setting equal to this average, the setting closest to the average shall be used. If there are two such settings equally close to the average, the higher of these temperature control settings shall be used. If the compartment temperature measured during the first test is higher than the standardized temperature, the second test shall be conducted with the controls set at the coldest settings. If the compartment temperature measured during the first test is lower than the standardized temperature, the second test shall be conducted with the controls set at the warmest settings. If the compartment temperatures measured during these two tests bound the standardized temperature, then these test results shall be used to determine energy consumption. If the compartment temperature measured with all controls set at their coldest settings is above the standardized temperature, a third test shall be performed with all controls set at their warmest settings and the result of this test shall be used with the result of the test performed with all controls set at their coldest settings to determine energy consumption. If the compartment temperature measured with all controls set at their warmest settings is below the standardized temperature, then the result of this test alone will be used to determine energy consumption.

3.2.2 Alternatively, a first test may be performed with all temperature controls set at their warmest setting. If the compartment temperature is below the standardized temperature, then the result of this test alone will be used to determine energy consumption. If the above condition is not met, then the unit shall be tested in accordance with 3.2.1 above.

3.2.3 Alternatively, a first test may be performed with all temperature controls set at their coldest setting. If the compartment temperature is above the standardized temperature, a second test shall be performed with all controls set at their warmest setting and the results of these two tests shall be used to determine energy consumption. If the above condition is not met, then the unit shall be tested in accordance with 3.2.1 above.

4. Test Period

Tests shall be performed by establishing the conditions set forth in section 2 and using the control settings as set forth in section 3 of this appendix.

4.1 Nonautomatic Defrost. If the model being tested has no automatic defrost system, the test time period shall start after steady-state conditions have been achieved and be no less than 3 hours in duration. During the test period, the compressor motor shall complete two or more whole compressor cycles. A compressor cycle is a complete ''on'' and a complete ''off'' period of the motor. If no ''off'' cycling will occur, as determined during the stabilization period, the test period shall be 3 hours. If incomplete cycling occurs (less than two compressor cycles during a 24-hour period), the results of the 24-hour period shall be used.

4.2 Automatic Defrost. If the model being tested has an automatic defrost system, the test time period shall start after steady-state conditions have been achieved and be from one point during a defrost period to the same point during the next defrost period. If the model being tested has a long-time automatic defrost system, the alternate provisions of 4.2.1 may be used. If the model being tested has a variable defrost control, the provisions of 4.2.2 shall apply.

4.2.1 Long-time Automatic Defrost. If the model being tested has a long-time automatic defrost system, the two-part test described in this section may be used. The first part is the same as the test for a unit having no defrost provisions (section 4.1). The second part would start when a defrost is initiated when the compressor ''on'' cycle is terminated prior to start of the defrost heater and terminates at the second turn ''on'' of the compressor or 4 hours from the initiation of the defrost heater, whichever comes first.

4.2.2 Variable Defrost Control. If the model being tested has a variable defrost control system, the test shall consist of the same two parts as the test for long-time automatic defrost (section 4.2.1).

5. Test Measurements

5.1 Temperature Measurements. Temperature measurements shall be made at the locations prescribed in Figure 7.2 of HRF–1–1979 (incorporated by reference; see §430.3) and shall be accurate to within ± 0.5 °F (0.3 °C). If the interior arrangements of the cabinet do not conform with those shown in Figure 7.2 of HRF–1–1979, the product may be tested by relocating the temperature sensors from the locations specified in the figures to avoid interference with hardware or components within the cabinet, in which case the specific locations used for the temperature sensors shall be noted in the test data records maintained by the manufacturer in accordance with 10 CFR 429.14, and the certification report shall indicate that non-standard sensor locations were used.

5.1.1 Measured Temperature. The measured temperature is to be the average of all sensor temperature readings taken at a particular time. Measurements shall be taken at regular intervals not to exceed four minutes.

5.1.2 Compartment Temperature. The compartment temperature for each test period shall be an average of the measured temperatures taken during one or more complete compressor cycles. One compressor cycle is one complete motor ''on'' and one complete motor ''off'' period. For long-time automatic defrost models, compartment temperature shall be that measured in the first part of the test period specified in 4.2.1. For models equipped with variable defrost controls, compartment temperatures shall be those measured in the first part of the test period specified in 4.2.2.

5.1.2.1 The number of complete compressor motor cycles over which the measured temperatures in a compartment are to be averaged to determine compartment temperature shall be equal to the number of minutes between measured temperature readings rounded up to the next whole minute or a number of complete cycles over a time period exceeding one hour. One of the compressor cycles shall be the last complete compressor cycle during the test period before start of the defrost control sequence for products with automatic defrost.

5.1.2.2 If no compressor motor cycling occurs, the compartment temperature shall be the average of the measured temperatures taken during the last thirty-two minutes of the test period.

5.1.2.3 If incomplete cycling occurs (less than one compressor cycle), the compartment temperature shall be the average of all readings taken during the last 3 hours of the last complete compressor ''on'' period.

5.1.3 Freezer Compartment Temperature. The freezer compartment temperature shall be calculated as:

$$TF = \frac{\sum_{i=1}^{F}(TF_i) \times (VF_i)}{\sum_{i=1}^{F}(VF_i)}$$

Where:

F is the total number of applicable freezer compartments, which include the first freezer compartment and any number of separate auxiliary freezer compartments;

TF_i is the compartment temperature of freezer compartment "i" determined in accordance with section 5.1.2; and

VF_i is the volume of freezer compartment "i".

5.2 Energy Measurements:

5.2.1 Per-day Energy Consumption. The energy consumption in kilowatt-hours per day for each test period shall be the energy expended during the test period as specified in section 4.1 adjusted to a 24 hour period.

The adjustment shall be determined as follows:

5.2.1.1 Nonautomatic and automatic defrost models. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

ET=(EP×1440×K)/T where

ET=test cycle energy expended in kilowatt-hours per day,

EP=energy expended in kilowatt-hours during the test period.

T=length of time of the test period in minutes,

1440=conversion factor to adjust to a 24 hour period in minutes per day, and

K=correction factor of 0.7 for chest freezers and 0.85 for upright freezers to adjust for average household usage, dimensionless.

5.2.1.2 Long-time Automatic Defrost. If the two part test method is used, the energy consumption in kilowatt-hours per day shall be calculated equivalent to:

ET = (1440 × K × EP1/T1) + (EP2 − EP1 × T2/T1)) × K × (12/CT)

Where:

ET, 1440, and K are defined in section 5.2.1.1;

EP1 = energy expended in kilowatt-hours during the first part of the test;

EP2 = energy expended in kilowatt-hours during the second part of the test;

CT = defrost timer run time or compressor run time between defrosts in hours required to cause it to go through a complete cycle, rounded to the nearest tenth of an hour;

12 = conversion factor to adjust for a 50 percent run time of the compressor in hours per day; and

T1 and T2 = length of time in minutes of the first and second test parts respectively.

5.2.1.3 Variable Defrost Control. The energy consumption in kilowatt-hours per day shall be calculated equivalent to:

ET = (1440 × K × EP1/T1) + (EP2 − (EP1 × T2/T1)) × K × (12/CT),

Where:

ET, K, and 1440 are defined in section 5.2.1.1 and EP1, EP2, T1, T2, and 12 are defined in section 5.2.1.2.

$CT = (CT_L \times CT_M)/(F \times (CT_M - CT_L) + CT_L)$

Where:

CT_L = least or shortest compressor run time between defrosts in hours rounded to the nearest tenth of an hour (greater than or equal to 6 hours but less than or equal to 12 hours);

CT_M = maximum compressor run time between defrosts in hours rounded to the nearest tenth of an hour (greater than CT_L but not more than 96 hours);

F = ratio of per day energy consumption in excess of the least energy and the maximum difference in per-day energy consumption and is equal to 0.20.

For variable defrost models with no values for CT_L and CT_M in the algorithm, the default values of 12 and 84 shall be used, respectively.

5.3 Volume measurements. The total refrigerated volume, VT, shall be measured in accordance with HRF–1–1979, section 3.20 and section 5.1 through 5.3.

6. Calculation of Derived Results From Test Measurements.

6.1 Adjusted Total Volume. The adjusted total volume, VA, for freezers under test shall be defined as:

VA=VT×CF

where

VA=adjusted total volume in cubic feet,

VT=total refrigerated volume in cubic feet, and

CF=Correction factor of 1.73, dimensionless.

6.2 Average Per Cycle Energy Consumption:

6.2.1 The average per-cycle energy consumption for a cycle type is expressed in kilowatt-hours per cycle to the nearest one hundredth (0.01) kilowatt-hour and shall depend upon the compartment temperature attainable as shown below.

6.2.1.1 If the compartment temperature is always below 0.0 °F. (−17.8 °C.), the average per-cycle energy consumption shall be equivalent to:

E=ET1

where

E=Total per-cycle energy consumption in kilowatt-hours per day.

ET is defined in 5.2.1, and

Number 1 indicates the test period during which the highest compartment temperature is measured.

6.2.1.2 If one of the compartment temperatures measured for a test period is greater than 0.0 °F (17.8 °C), the average per-cycle energy consumption shall be equivalent to:

$$E = ET1 + ((ET2 - ET1) \times (0.0 - TF1)/(TF2 - TF1))$$

Where:

E is defined in 6.2.1.1;

ET is defined in 5.2.1;

TF = freezer compartment temperature determined according to 5.1.3 in degrees F;

The numbers 1 and 2 indicate measurements taken during the first and second test period as appropriate; and

0.0 = Standardized compartment temperature in degrees F.

6.2.2 Variable Anti-Sweat Heater Models. The standard cycle energy consumption of an electric freezer with a variable anti-sweat heater control (E_{std}), expressed in kilowatt-hours per day, shall be calculated equivalent to:

E_{std} = E + (Correction Factor) where E is determined by 6.2.1.1, or 6.2.1.2, whichever is appropriate, with the anti-sweat heater switch in the "off" position or, for a product without an anti-sweat heater switch, the anti-sweat heater in its lowest energy use state.

Correction Factor = (Anti-sweat Heater Power × System-loss Factor) × (24 hrs/1 day) × (1 kW/1000 W)

Where:

Anti-sweat Heater Power = 0.034 * (Heater Watts at 5%RH)
+ 0.211 * (Heater Watts at 15%RH)
+ 0.204 * (Heater Watts at 25%RH)
+ 0.166 * (Heater Watts at 35%RH)
+ 0.126 * (Heater Watts at 45%RH)
+ 0.119 * (Heater Watts at 55%RH)
+ 0.069 * (Heater Watts at 65%RH)
+ 0.047 * (Heater Watts at 75%RH)
+ 0.008 * (Heater Watts at 85%RH)
+ 0.015 * (Heater Watts at 95%RH)

Heater Watts at a specific relative humidity = the nominal watts used by all heaters at that specific relative humidity, 72 °F (22.2 °C) ambient, and DOE reference freezer (FZ) average temperature of 0 °F (−17.8 °C).

System-loss Factor = 1.3.

7. Test Procedure Waivers

To the extent that the procedures contained in this appendix do not provide a means for determining the energy consumption of a freezer, a manufacturer must obtain a waiver under 10 CFR 430.27 to establish an acceptable test procedure for each such product. Such instances could, for example, include situations where the test set-up for a particular freezer basic model is not clearly defined by the provisions of section 2. For details regarding the criteria and procedures for obtaining a waiver, please refer to 10 CFR 430.27.

[47 FR 34528, Aug. 10, 1982; 48 FR 13013, Mar. 29, 1983, as amended at 54 FR 36241, Aug. 31, 1989; 54 FR 38788, Sept. 20, 1989; 75 FR 78871, Dec. 16, 2010; 76 FR 12502, Mar. 7, 2011; 76 FR 24782, May 2, 2011]

APPENDIX C TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF DISHWASHERS

The provisions of this appendix C shall apply to products manufactured after September 29, 2003. The restriction on representations concerning energy use or efficiency in 42 U.S.C. 6293(c)(2) shall apply on February 25, 2004.

1. Definitions

1.1 *AHAM* means the Association of Home Appliance Manufacturers.

1.2 *Compact dishwasher* means a dishwasher that has a capacity of less than eight place settings plus six serving pieces as specified in ANSI/AHAM DW–1 (*see* § 430.22), using the test load specified in section 2.7 of this appendix.

1.3 *Cycle* means a sequence of operations of a dishwasher which performs a complete dishwashing function, and may include variations or combinations of washing, rinsing, and drying.

1.4 *Cycle type* means any complete sequence of operations capable of being preset on the dishwasher prior to the initiation of machine operation.

1.5 *Non-soil-sensing dishwasher* means a dishwasher that does not have the ability to adjust automatically any energy consuming aspect of a wash cycle based on the soil load of the dishes.

1.6 *Normal cycle* means the cycle type recommended by the manufacturer for completely washing a full load of normally soiled dishes including the power-dry feature.

1.7 *Power-dry feature* means the introduction of electrically generated heat into the washing chamber for the purpose of improving the drying performance of the dishwasher.

1.8 *Preconditioning cycle* means any cycle that includes a fill, circulation, and drain to ensure that the water lines and sump area of the pump are primed.

1.9 *Sensor heavy response* means, for standard dishwashers, the set of operations in a soil-sensing dishwasher for completely washing a load of dishes, four place settings of which are soiled according to ANSI/AHAM DW–1 (Incorporated by reference, *see* §430.22). For compact dishwashers, this definition is the same, except that two soiled place settings are used instead of four.

1.10 *Sensor light response* means, for both standard and compact dishwashers, the set of operations in a soil-sensing dishwasher for completely washing a load of dishes, one place setting of which is soiled with half of the gram weight of soils for each item specified in a single place setting according to ANSI/AHAM DW–1 (Incorporated by reference, *see* §430.22).

1.11 *Sensor medium response* means, for standard dishwashers, the set of operations in a soil-sensing dishwasher for completely washing a load of dishes, two place settings of which are soiled according to ANSI/AHAM DW–1 (Incorporated by reference, see §430.22). For compact dishwashers, this definition is the same, except that one soiled place setting is used instead of two.

1.12 *Soil-sensing dishwasher* means a dishwasher that has the ability to adjust any energy consuming aspect of a wash cycle based on the soil load of the dishes.

1.13 *Standard dishwasher* means a dishwasher that has a capacity equal to or greater than eight place settings plus six serving pieces as specified in ANSI/AHAM DW–1 (Incorporated by reference, see §430.22), using the test load specified in section 2.7 of this appendix.

1.14 *Standby mode* means the lowest power consumption mode which cannot be switched off or influenced by the user and that may persist for an indefinite time when the dishwasher is connected to the main electricity supply and used in accordance with the manufacturer's instructions.

1.15 *Truncated normal cycle* means the normal cycle interrupted to eliminate the power-dry feature after the termination of the last rinse operation.

1.16 *Truncated sensor heavy response* means the sensor heavy response interrupted to eliminate the power-dry feature after the termination of the last rinse operation.

1.17 *Truncated sensor light response* means the sensor light response interrupted to eliminate the power-dry feature after the termination of the last rinse operation.

1.18 *Truncated sensor medium response* means the sensor medium response interrupted to eliminate the power-dry feature after the termination of the last rinse operation.

1.19 *Water-heating dishwasher* means a dishwasher which, as recommended by the manufacturer, is designed for heating cold inlet water (nominal 50 °F) or designed for heating water with a nominal inlet temperature of 120 °F. Any dishwasher designated as water-heating (50 °F or 120 °F inlet water) must provide internal water heating to above 120 °F in at least one wash phase of the normal cycle.

2. Testing conditions:

2.1 *Installation Requirements.* Install the dishwasher according to the manufacturer's instructions. A standard or compact under-counter or under-sink dishwasher must be tested in a rectangular enclosure constructed of nominal 0.374 inch (9.5 mm) plywood painted black. The enclosure must consist of a top, a bottom, a back, and two sides. If the dishwasher includes a counter top as part of the appliance, omit the top of the enclosure. Bring the enclosure into the closest contact with the appliance that the configuration of the dishwasher will allow.

2.2 *Electrical energy supply.*

2.2.1 *Dishwashers that operate with an electrical supply of 115 volts.* Maintain the electrical supply to the dishwasher at 115 volts ±2 percent and within 1 percent of the nameplate frequency as specified by the manufacturer.

2.2.2 *Dishwashers that operate with an electrical supply of 240 volts.* Maintain the electrical supply to the dishwasher at 240 volts ±2 percent and within 1 percent of its nameplate frequency as specified by the manufacturer.

2.3 *Water temperature.* Measure the temperature of the water supplied to the dishwasher using a temperature measuring device as specified in section 3.1 of this appendix.

2.3.1 *Dishwashers to be tested at a nominal 140 °F inlet water temperature.* Maintain the water supply temperature at 140° ±2 °F.

2.3.2 *Dishwashers to be tested at a nominal 120 °F inlet water temperature.* Maintain the water supply temperature at 120° ±2 °F.

2.3.3 *Dishwashers to be tested at a nominal 50 °F inlet water temperature.* Maintain the water supply temperature at 50° ±2 °F.

2.4 *Water pressure.* Using a water pressure gauge as specified in section 3.4 of this appendix, maintain the pressure of the water supply at 35 ±2.5 pounds per square inch gauge (psig) when the water is flowing.

2.5 *Ambient and machine temperature.* Using a temperature measuring device as specified in section 3.1 of this appendix, maintain the room ambient air temperature at 75° ±5 °F, and ensure that the dishwasher and the test load are at room ambient temperature at the start of each test cycle.

2.6 *Test Cycle and Load.*

2.6.1 *Non-soil-sensing dishwashers to be tested at a nominal inlet temperature of 140 °F.* These units must be tested on the normal cycle and truncated normal cycle without a test load if the dishwasher does not heat water in the normal cycle.

2.6.2 *Non-soil-sensing dishwashers to be tested at a nominal inlet temperature of 50 °F or 120 °F.* These units must be tested on the normal cycle with a clean load of eight place settings plus six serving pieces, as specified in section 2.7 of this appendix. If the capacity of the dishwasher, as stated by the manufacturer, is less than eight place settings, then the test load must be the stated capacity.

2.6.3 *Soil-sensing dishwashers to be tested at a nominal inlet temperature of 50 °F, 120 °F, or 140 °F.* These units must be tested first for the sensor heavy response, then tested for the sensor medium response, and finally for the sensor light response with the following combinations of soiled and clean test loads.

2.6.3.1 For tests of the sensor heavy response, as defined in section 1.9 of this appendix:

(A) For standard dishwashers, the test unit is to be loaded with a total of eight place settings plus six serving pieces as specified in section 2.7 of this appendix. Four of the eight place settings must be soiled according to ANSI/AHAM DW–1 (Incorporated by reference, *see* §430.22) while the remaining place settings, serving pieces, and all flatware are not soiled.

(B) For compact dishwashers, the test unit is to be loaded with four place settings plus six serving pieces as specified in section 2.7 of this appendix. Two of the four place settings must be soiled according to ANSI/AHAM DW–1 (Incorporated by reference, *see* §430.22) while the remaining place settings, serving pieces, and all flatware are not soiled.

2.6.3.2 For tests of the sensor medium response, as defined in section 1.11 of this appendix:

(A) For standard dishwashers, the test unit is to be loaded with a total of eight place settings plus six serving pieces as specified in section 2.7 of this appendix. Two of the eight place settings must be soiled according to ANSI/AHAM DW–1 (Incorporated by reference, *see* §430.22) while the remaining place settings, serving pieces, and all flatware are not soiled.

(B) For compact dishwashers, the test unit is to be loaded with four place settings plus six serving pieces as specified in section 2.7 of this appendix. One of the four place settings must be soiled according to ANSI/AHAM DW–1 (Incorporated by reference, *see* §430.22) while the remaining place settings, serving pieces and all flatware are not soiled.

2.6.3.3 For tests of the sensor light response, as defined in section 1.10 of this appendix:

(A) For standard dishwashers, the test unit is to be loaded with a total of eight place settings plus six serving pieces as specified in section 2.7 of this appendix. One of the eight place settings must be soiled with half of the soil load specified for a single place setting according to ANSI/AHAM DW–1 (Incorporated by reference, *see* §430.22) while the remaining place settings, serving pieces, and all flatware are not soiled.

(B) For compact dishwashers, the test unit is to be loaded with four place settings plus six serving pieces as specified in section 2.7 of this appendix. One of the four place settings must be soiled with half of the soil load specified for a single place setting according to the ANSI/AHAM DW–1 (Incorporated by reference, *see* §430.22) while the remaining place settings, serving pieces, and all flatware are not soiled.

2.7 *Test Load.*

Dishware/glassware/flatware item	Primary source	Description	Primary No.	Alternate source	Alternate source No.
Dinner Plate	Corning Comcor®/Corelle®	10 inch Dinner Plate	6003893		
Bread and Butter Plate	Corning Comcor®/Corelle®	6.75 inch Bread & Butter	6003887	Arzberg	8500217100
Fruit Bowl	Corning Comcor®/Corelle®	10 oz. Dessert Bowl	6003899	Arzberg	3820513100
Cup	Corning Comcor®/Corelle®	8 oz. Ceramic Cup	6014162	Arzberg	3824732100
Saucer	Corning Comcor®/Corelle®	6 inch Saucer	6010972	Arzberg	3824731100
Serving Bowl	Corning Comcor®/Corelle®	1 qt. Serving Bowl	6003911		
Platter	Corning Comcor®/Corelle®	9.5 inch Oval Platter	6011655		
Glass-Iced Tea	Libbey		551 HT		
Flatware—Knife	Oneida®—Accent		2619KPVF		
Flatware—Dinner Fork	Oneida®—Accent		2619FRSF		
Flatware—Salad Fork	Oneida®—Accent		2619FSLF		
Flatware—Teaspoon	Oneida®—Accent		2619STSF		
Flatware—Serving Fork	Oneida®—Flight		2865FCM		
Flatware—Serving Spoon	Oneida®—Accent		2619STBF		

2.8 *Detergent*. Use half the quantity of detergent specified according to ANSI/AHAM DW–1 (Incorporated by reference, *see* § 430.22).

2.9 *Testing requirements*. Provisions in this appendix pertaining to dishwashers that operate with a nominal inlet temperature of 50 °F or 120 °F apply only to water-heating dishwashers as defined in section 1.19 of this appendix.

2.10 *Preconditioning requirements*. Precondition the dishwasher by establishing the testing conditions set forth in sections 2.1 through 2.5 of this appendix. Set the dishwasher to the preconditioning cycle as defined in section 1.8 of this appendix, without using a test load, and initiate the cycle.

3. Instrumentation

Test instruments must be calibrated annually.

3.1 *Temperature measuring device*. The device must have an error no greater than ±1 °F over the range being measured.

3.2 *Timer*. Time measurements for each monitoring period shall be accurate to within 2 seconds.

3.3 *Water meter*. The water meter must have a resolution of no larger than 0.1 gallons and a maximum error no greater than ±1.5 percent of the measured flow rate for all water temperatures encountered in the test cycle.

3.4 *Water pressure gauge*. The water pressure gauge must have a resolution of one pound per square inch (psi) and must have an error no greater than 5 percent of any measured value over the range of 35 ±2.5 psig.

3.5 *Watt-hour meter*. The watt-hour meter must have a resolution of 1 watt-hour or less and a maximum error of no more than 1 percent of the measured value for any demand greater than 50 watts.

3.6 *Standby wattmeter*. The standby wattmeter must have a resolution of 0.1 watt or less, a maximum error of no more than 1 percent of the measured value, and must be capable of operating within the stated tolerances for input voltages up to 5 percent total harmonic distortion. The standby wattmeter must be capable of operating at frequencies from 47 hertz through 63 hertz. Power measurements must have a crest factor of 3 or more at currents of 2 amps RMS or less.

3.7 *Standby watt-hour meter*. The standby watt-hour meter must meet all the requirements of the standby wattmeter and must accumulate watt-hours at a minimum power level of 20 milliwatts.

4. Test Cycle and Measurements

4.1 *Test cycle*. Perform a test cycle by establishing the testing conditions set forth in section 2 of this appendix, setting the dishwasher to the cycle type to be tested, initiating the cycle, and allowing the cycle to proceed to completion.

4.2 *Machine electrical energy consumption*. Measure the machine electrical energy consumption, M, expressed as the number of kilowatt-hours of electricity consumed by the machine during the entire test cycle, using a water supply temperature as set forth in section 2.3 of this appendix and using a watt-hour meter as specified in section 3.5 of this appendix.

4.3 *Water consumption*. Measure the water consumption, V, expressed as the number of gallons of water delivered to the machine during the entire test cycle, using a water meter as specified in section 3.3 of this appendix.

4.4 *Standby power*. Connect the dishwasher to a standby wattmeter or a standby watt-hour meter as specified in sections 3.6 and 3.7, respectively, of this appendix. Select the conditions necessary to achieve operation in the standby mode as defined in section 1.14 of this appendix. Monitor the power consumption but allow the dishwasher to stabilize for at least 5 minutes. Then monitor the power consumption for at least an additional 5 minutes. If the power level does not change by more than 5 percent from the maximum observed value during the later 5 minutes and there is no cyclic or pulsing behavior of the load, the load can be considered stable. For stable operation, standby power, S_m, can be recorded directly from the standby watt meter in watts or accumulated using the standby watt-hour meter over a period of at least 5 minutes. For unstable operation, the energy must be accumulated using the standby watt-hour meter over a period of at least 5 minutes and must capture the energy use over one or more complete cycles. Calculate the average standby power, S_m, expressed in watts by dividing the accumulated energy consumption by the duration of the measurement period.

5. Calculation of Derived Results From Test Measurements

5.1 *Machine energy consumption*.

5.1.1 *Machine energy consumption for non-soil-sensing electric dishwashers*. Take the value recorded in section 4.2 of this appendix as the per-cycle machine electrical energy consumption. Express the value, M, in kilowatt-hours per cycle.

5.1.2 *Machine energy consumption for soil-sensing electric dishwashers*. The machine energy consumption for the sensor normal cycle, M, is defined as:

$$M = (M_{hr} \times F_{hr}) + (M_{mr} \times F_{mr}) + (M_{lr} \times F_{lr})$$

where,

M_{hr} = the value recorded in section 4.2 of this appendix for the test of the sensor heavy response, expressed in kilowatt-hours per cycle,

M_{mr} = the value recorded in section 4.2 of this appendix for the test of the sensor medium response, expressed in kilowatt-hours per cycle,

M_{lr} = the value recorded in section 4.2 of this appendix for the test of the sensor light response, expressed in kilowatt-hours per cycle,

F_{hr} = the weighting factor based on consumer use of heavy response = 0.05,

F_{mr} = the weighting factor based on consumer use of medium response = 0.33,

F_{lr} = the weighting factor based on consumer use of light response = 0.62.

5.2 Drying energy.

5.2.1 *Drying energy consumption for non-soil-sensing electric dishwashers.* Calculate the amount of energy consumed using the power-dry feature after the termination of the last rinse option of the normal cycle. Express the value, E_D, in kilowatt-hours per cycle.

5.2.2 *Drying energy consumption for soil-sensing electric dishwashers.* The drying energy consumption, E_D, for the sensor normal cycle is defined as:

$$E_D = (E_{Dhr} + E_{Dmr} + E_{Dlr})/3$$

Where,

E_{Dhr} = energy consumed using the power-dry feature after the termination of the last rinse option of the sensor heavy response, expressed in kilowatt-hours per cycle,

E_{Dmr} = energy consumed using the power-dry feature after the termination of the last rinse option of the sensor medium response, expressed in kilowatt-hours per cycle,

E_{Dlr} = energy consumed using the power-dry feature after the termination of the last rinse option of the sensor light response, expressed in kilowatt-hours per cycle.

5.3 *Water consumption.*

5.3.1 *Water consumption for non-soil-sensing dishwashers using electrically heated, gas-heated, or oil-heated water.*

Take the value recorded in section 4.3 of this appendix as the per-cycle water energy consumption. Express the value, V, in gallons per cycle.

5.3.2 *Water consumption for soil-sensing dishwashers using electrically heated, gas-heated, or oil-heated water.*

The water consumption for the sensor normal cycle, V, is defined as:

$$V = (V_{hr} \times F_{hr}) + (V_{mr} \times F_{mr}) + (V_{lr} \times F_{lr})$$

Where,

V_{hr} = the value recorded in section 4.3 of this appendix for the test of the sensor heavy response, expressed in gallons per cycle,

V_{mr} = the value recorded in section 4.3 of this appendix for the test of the sensor medium response, expressed in gallons per cycle,

V_{lr} = the value recorded in section 4.3 of this appendix for the test of the sensor light response, expressed in gallons per cycle,

F_{hr} = the weighting factor based on consumer use of heavy response = 0.05,

F_{mr} = the weighting factor based on consumer use of medium response = 0.33,

F_{lr} = the weighting factor based on consumer use of light response = 0.62.

5.4 *Water energy consumption for non-soil-sensing or soil-sensing dishwashers using electrically heated water.*

5.4.1 *Dishwashers that operate with a nominal 140 °F inlet water temperature, only.* For the normal and truncated normal test cycle, calculate the water energy consumption, W, expressed in kilowatt-hours per cycle and defined as:

$$W = V \times T \times K$$

Where,

V = water consumption in gallons per cycle, as determined in section 5.3.1 of this appendix,

T = nominal water heater temperature rise = 90 °F,

K = specific heat of water in kilowatt-hours per gallon per degree Fahrenheit = 0.0024.

5.4.2 *Dishwashers that operate with a nominal inlet water temperature of 120 °F.* For the normal and truncated normal test cycle, calculate the water energy consumption, W, expressed in kilowatt-hours per cycle and defined as:

$$W = V \times T \times K$$

Where,

V = water consumption in gallons per cycle, as determined in section 5.3.1 of this appendix,

T = nominal water heater temperature rise = 70 °F,

K = specific heat of water in kilowatt-hours per gallon per degree Fahrenheit = 0.0024.

5.5 *Water energy consumption per cycle using gas-heated or oil-heated water.*

5.5.1 *Dishwashers that operate with a nominal 140 °F inlet water temperature, only.*

For each test cycle, calculate the water energy consumption using gas-heated or oil-heated water, W_g, expressed in Btu's per cycle and defined as:

$$W_g = V \times T \times C/e$$

Where,

V = reported water consumption in gallons per cycle, as determined in section 5.3.2 of this appendix,

T = nominal water heater temperature rise = 90 °F,

C = specific heat of water in Btu's per gallon per degree Fahrenheit = 8.2,

e = nominal gas or oil water heater recovery efficiency = 0.75.

5.5.2 *Dishwashers that operate with a nominal inlet water temperature of 120 °F.* For each test cycle, calculate the water energy consumption using gas heated or oil heated water, W_g, expressed in Btu's per cycle and defined as:

$$Wg = V \times T \times C/e$$

Where,

V = reported water consumption in gallons per cycle, as determined in section 5.3.2 of this appendix,

T = nominal water heater temperature rise = 70 °F,

C = specific heat of water in Btu's per gallon per degree Fahrenheit = 8.2,

e = nominal gas or oil water heater recovery efficiency = 0.75.

5.6 *Annual standby energy consumption*. Calculate the estimated annual standby energy consumption. First determine the number of standby hours per year, H_s, defined as:

$H_s = H - (N \times L)$.

Where,

H = the total number of hours per year = 8766 hours per year,

N = the representative average dishwasher use of 215 cycles per year,

L = the average of the duration of the normal cycle and truncated normal cycle, for non-soil-sensing dishwashers with a truncated normal cycle; the duration of the normal cycle, for non-soil-sensing dishwashers without a truncated normal cycle; the average duration of the sensor light response, truncated sensor light response, sensor medium response, truncated sensor medium response, sensor heavy response, and truncated sensor heavy response, for soil-sensing dishwashers with a truncated cycle option; the average duration of the sensor light response, sensor medium response, and sensor heavy response, for soil-sensing dishwashers without a truncated cycle option.

Then calculate the estimated annual standby power use, S, expressed in kilowatt-hours per year and defined as:

$S = S_m \times ((H_s)/1000)$

Where,

S_m = the average standby power in watts as determined in section 4.4 of this appendix.

[68 FR 51900, Aug. 29, 2003]

Appendix D to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Clothes Dryers

NOTE: Manufacturers must continue to use appendix D to subpart B of part 430 until the energy conservation standards for clothes dryers at 10 CFR 430.32(h) are amended to require mandatory compliance using appendix D1.

1. Definitions

1.1 ''AHAM'' means the Association of Home Appliance Manufacturers.

1.2 ''Bone dry'' means a condition of a load of test clothes which has been dried in a dryer at maximum temperature for a minimum of 10 minutes, removed and weighed before cool down, and then dried again for 10-minute periods until the final weight change of the load is 1 percent or less.

1.3 ''Compact'' or compact size'' means a clothes dryer with a drum capacity of less than 4.4 cubic feet.

1.4 ''Cool down'' means that portion of the clothes drying cycle when the added gas or electric heat is terminated and the clothes continue to tumble and dry within the drum.

1.5 ''Cycle'' means a sequence of operation of a clothes dryer which performs a clothes drying operation, and may include variations or combinations of the functions of heating, tumbling and drying.

1.6 ''Drum capacity'' means the volume of the drying drum in cubic feet.

1.7 ''HLD–1'' means the test standard promulgated by AHAM and titled ''AHAM Performance Evaluation Procedure for Household Tumble Type Clothes Dryers'', June 1974, and designated as HLD–1.

1.8 ''HLD–2EC'' means the test standard promulgated by AHAM and titled ''Test Method for Measuring Energy Consumption of Household Tumble Type Clothes Dryers,'' December 1975, and designated as HLD–2EC.

1.9 ''Standard size'' means a clothes dryer with a drum capacity of 4.4 cubic feet or greater.

1.10 ''Moisture content'' means the ratio of the weight of water contained by the test load to the bone-dry weight of the test load, expressed as a percent.

1.11 ''Automatic termination control'' means a dryer control system with a sensor which monitors either the dryer load temperature or its moisture content and with a controller which automatically terminates the drying process. A mark or detent which indicates a preferred automatic termination control setting must be present if the dryer is to be classified as having an ''automatic termination control.'' A mark is a visible single control setting on one or more dryer controls.

1.12 ''Temperature sensing control'' means a system which monitors dryer exhaust air temperature and automatically terminates the dryer cycle.

1.13 ''Moisture sensing control'' means a system which utilizes a moisture sensing element within the dryer drum that monitors the amount of moisture in the clothes and automatically terminates the dryer cycle.

2. Testing Conditions

2.1 *Installation*. Install the clothes dryer in accordance with manufacturer's instructions. The dryer exhaust shall be restricted by adding the AHAM exhaust simulator described in 3.3.5 of HLD–1. All external joints should be taped to avoid air leakage. Disconnect all console light or other lighting systems on the clothes dryer which do not consume more than 10 watts during the clothes dryer test cycle.

2.2 *Ambient temperature and humidity*. Maintain the room ambient air temperature at 75 ±3 °F and the room relative humidity at 50±10 percent relative humidity.

2.3 Energy supply.

2.3.1 *Electrical supply*. Maintain the electrical supply at the clothes dryer terminal block within 1 percent of 120/240 or 120/208Y or 120 volts as applicable to the particular terminal block wiring system and within 1 percent of the nameplate frequency as specified by the manufacturer. If the dryer has a dual voltage conversion capability, conduct test at the highest voltage specified by the manufacturer.

2.3.2 *Gas supply*.

2.3.2.1 *Natural gas*. Maintains the gas supply to the clothes dryer at a normal inlet test pressure immediately ahead of all controls at 7 to 10 inches of water column. If the clothes dryer is equipped with a gas appliance pressure regulator, the regulator outlet pressure at the normal test pressure shall be approximately that recommended by the manufacturer. The hourly Btu rating of the burner shall be maintained within ±5 percent of the rating specified by the manufacturer. The natural gas supplied should have a heating value of approximately 1,025 Btu's per standard cubic foot. The actual heating value, H_n2, in Btu's per standard cubic foot, for the natural gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using a standard continuous flow calorimeter as described in 2.4.6 or by the purchase of bottled natural gas whose Btu rating is certified to be at least as accurate a rating as could be obtained from measurements with a standard continuous flow calorimeter as described in 2.4.6.

2.3.2.2 *Propane gas*. Maintain the gas supply to the clothes dryer at a normal inlet test pressure immediately ahead of all controls at 11 to 13 inches of water column. If the clothes dryer is equipped with a gas appliance pressure regulator, the regulator outlet pressure at the normal test pressure shall be approximately that recommended by the manufacturer. The hourly Btu rating of the burner shall be maintained within ±5 percent of the rating specified by the manufacturer. The propane gas supplied should have a heating value of approximately 2,500 Btu's per standard cubic foot. The actual heating value, H_p, in Btu's per standard cubic foot, for the propane gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using a standard continuous flow calorimeter as described in 2.4.6 or by the purchase of bottled gas whose Btu rating is certified to be at least as accurate a rating as could be obtained from measurement with a standard continuous calorimeter as described in 2.4.6.

2.4 *Instrumentation*. Perform all test measurements using the following instruments as appropriate.

2.4.1 *Weighing scale for test cloth*. The scale shall have a range of 0 to a maximum of 30 pounds with a resolution of at least 0.2 ounces and a maximum error no greater than 0.3 percent of any measured value within the range of 3 to 15 pounds.

2.4.1.2 *Weighing scale for drum capacity measurements*. The scale should have a range of 0 to a maximum of 500 pounds with resolution of 0.50 pounds and a maximum error no greater than 0.5 percent of the measured value.

2.4.2 *Kilowatt-hour meter*. The kilowatt-hour meter shall have a resolution of 0.001 kilowatt-hours and a maximum error no greater than 0.5 percent of the measured value.

2.4.3 *Gas meter*. The gas meter shall have a resolution of 0.001 cubic feet and a maximum error no greater than 0.5 percent of the measured value.

2.4.4 *Dry and wet bulb psychrometer*. The dry and wet bulb psychrometer shall have an error no greater than ±1 °F.

2.4.5 *Temperature*. The temperature sensor shall have an error no greater than ±1 °F.

2.4.6 *Standard Continuous Flow Calorimeter*. The Calorimeter shall have an operating range of 750 to 3,500 Btu per cubic feet. The maximum error of the basic calorimeter shall be no greater than 0.2 percent of the actual heating value of the gas used in the test. The indicator readout shall have a maximum error no greater than 0.5 percent of the measured value within the operating range and a resolution of 0.2 percent of the full scale reading of the indicator instrument.

2.5 *Lint trap*. Clean the lint trap thoroughly before each test run.

2.6 *Test cloths*.

2.6.1 *Energy test cloth*. The energy test cloth shall be clean and consist of the following:

(a) Pure finished bleached cloth, made with a momie or granite weave, which is a blended fabric of 50 percent cotton and 50 percent polyester and weighs within +10 percent of 5.75 ounces per square yard after test cloth preconditioning and has 65 ends on the warp and 57 picks on the fill. The individual warp and fill yarns are a blend of 50 percent cotton and 50 percent polyester fibers.

(b) Cloth material that is 24 inches by 36 inches and has been hemmed to 22 inches by 34 inches before washing. The maximum shrinkage after five washes shall not be more than four percent on the length and width.

(c) The number of test runs on the same energy test cloth shall not exceed 25 runs.

2.6.2 *Energy stuffer cloths*. The energy stuffer cloths shall be made from energy test cloth material and shall consist of pieces of material that are 12 inches by 12 inches and have been hemmed to 10 inches by 10 inches before washing. The maximum shrinkage after five washes shall not be more than four percent on the length and width. The number of test runs on the same energy stuffer cloth shall not exceed 25 runs after test cloth preconditioning.

2.6.3 *Test Cloth Preconditioning.*

A new test cloth load and energy stuffer cloths shall be treated as follows:

(1) Bone dry the load to a weight change of ±1 percent, or less, as prescribed in Section 1.2.

(2) Place test cloth load in a standard clothes washer set at the maximum water fill level. Wash the load for 10 minutes in soft water (17 parts per million hardness or less), using 6.0 grams of AHAM Standard Test Detergent, IIA, per gallon of water. Wash water temperature is to controlled at 140°±5 °F (60°±2.7 °C). Rinse water temperature is to be controlled at 100°±5 °F (37.7±2.7 °C).

(3) Rinse the load again at the same water temperature.

(4) Bone dry the load as prescribed in Section 1.2 and weigh the load.

(5) This procedure is repeated until there is a weight change of one percent or less.

(6) A final cycle is to be a hot water wash with no detergent, followed by two warm water rinses.

2.7 *Test loads.*

2.7.1 *Compact size dryer load.* Prepare a bone-dry test load of energy cloths which weighs 3.00 pounds ±.03 pounds. Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths, with no more than five stuffer cloths per load. Dampen the load by agitating it in water whose temperature is 100° ±5 °F and consists of 0 to 17 parts per million hardness for approximately two minutes in order to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 66.5 percent to 73.5 percent of the bone-dry weight of the test load.

2.7.2 *Standard size dryer load.* Prepare a bone-dry test load of energy cloths which weighs 7.00 pounds ±.07 pounds. Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths, with no more than five stuffer cloths per load. Dampen the load by agitating it in water whose temperature is 100° ±5 °F and consists of 0 to 17 parts per million hardness for approximately two minutes in order to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 66.5 percent to 73.5 percent of the bone-dry weight of the test load.

2.7.3 *Method of loading.* Load the energy test cloths by grasping them in the center, shaking them to hang loosely and then dropping them in the dryer at random.

2.8 *Clothes dryer preconditioning.* Before any test cycle, operate the dryer without a test load in the non-heat mode for 15 minutes or until the discharge air temperature is varying less than 1 °F for 10 minutes, which ever is longer, in the test installation location with the ambient conditions within the specified rest condition tolerances of 2.2.

3. Test Procedures and Measurements

3.1 *Drum capacity.* Measure the drum capacity by sealing all openings in the drum except the loading port with a plastic bag, and ensure that all corners and depressions are filled and that there are no extrusions of the plastic bag through the opening in the drum. Support the dryer's rear drum surface on a platform scale to prevent deflection of the dryer, and record the weight of the empty dryer. Fill the drum with water to a level determined by the intersection of the door plane and the loading port. Record the temperature of the water and then the weight of the dryer with the added water and then determine the mass of the water in pounds. Add or subtract the appropriate volume depending on whether or not the plastic bag protrudes into the drum interior. The drum capacity is calculated as follows:

$C=w/d$

C= capacity in cubic feet.

w= weight of water in pounds.

d= density of water at the measured temperature in pounds per cubic feet.

3.2 *Dryer loading.* Load the dryer as specified in 2.7.

3.3 *Test cycle.* Operate the clothes dryer at the maximum temperature setting and, if equipped with a timer, at the maximum time setting and dry the test load until the moisture content of the test load is between 2.5 percent to 5.0 percent of the bone-dry weight of the test load, but do not permit the dryer to advance into cool down. If required, reset the timer or automatic dry control.

3.4 *Data recording.* Record for each test cycle:

3.4.1 Bone-dry weight of the test load described in 2.7.

3.4.2 Moisture content of the wet test load before the test, as described in 2.7.

3.4.3 Moisture content of the dry test load obtained after the test described in 3.3.

3.4.4 Test room conditions, temperature and percent relative humidity described in 2.2.

3.4.5 For electric dryers—the total kilowatt-hours of electric energy, E_t, consumed during the test described in 3.3.

3.4.6 For gas dryers:

3.4.6.1 Total kilowatt-hours of electrical energy, E_{te}, consumed during the test described in 3.3.

3.4.6.2 Cubic feet of gas per cycle, E_{tg}, consumed during the test described in 3.3.

3.4.6.3 On gas dryers using a continuously burning pilot light—the cubic feet of gas, E_{pg}, consumed by the gas pilot light in one hour.

3.4.6.4 Correct the gas heating value, GEF, as measured in 2.3.2.1 and 2.3.2.2, to standard pressure and temperature conditions in accordance with U.S. Bureau of Standards, circular C417, 1938. A sample calculation is illustrated in appendix E of HLD–1.

3.5 *Test for automatic termination field use factor credits.* Credit for automatic termination can be claimed for those dryers which meet the requirements for either temperature-sensing control, 1.12, or moisture sensing control, 1.13, and having present the appropriate mark or detent feed defined in 1.11.

4. Calculation of Derived Results From Test Measurements

4.1 *Total per-cycle electric dryer energy consumption.* Calculate the total electric dryer energy consumption per cycle, E_{ce} expressed in kilowatt-hours per cycle and defined as:

$E_{ce}=[66/W_w - W_d)]\times E_{tt}\times FU$

E_t=the energy recorded in 3.4.5.

66=an experimentally established value for the percent reduction in the moisture content of the test load during a laboratory test cycle expressed as a percent.

FU=Field use factor.

=1.18 for time termination control systems.

=1.04 for automatic control systems which meet the requirements of the definitions for automatic termination controls in 1.11.1, 1.12 and 1.13.

W_w=the moisture content of the wet test load as recorded in 3.4.2.

W_d=the moisture content of the dry test load as recorded in 3.4.3.

4.2 *Per-cycle gas dryer electrical energy consumption.* Calculate the gas dryer electrical energy consumption per cycle, E_{ge}, expressed in kilowatt-hours per cycle and defined as:

$E_{GE}=[66/(W_w - W_d)]\times E_{te}\times FU$

E_{TE}=the energy recorded in 3.4.6.1

FU, 66, W_w, W_d as defined in 4.1

4.3 *Per-cycle gas dryer gas energy consumption.* Calculate the gas dryer gas energy consumption per cycle, $E_{ge.}$ expressed in Btu's per cycle as defined as:

$E_{GG}=[66/(W_w - W_d)]\times E_{tg}\times FU\times GEF$

E_{TG}=the energy recorded in 3.4.6.2

GEF=corrected gas heat value (Btu per cubic feet) as defined in 3.4.6.4

FU, 66, W_w W_d as defined in 4.1

4.4 *Per-cycle gas dryer continuously burning pilot light gas energy consumption.* Calculate the gas dryer continuously burning pilot light gas energy consumption per cycle, E_{up} expressed in Btu's per cycle and defined as:

$E_{up}=E_{pg}\times(8760-140/416)\times GEF$

E_{pg}=the energy recorded in 3.4.6.3

8760=number of hours in a year

416=representative average number of clothes dryer cycles in a year

140=estimated number of hours that the continuously burning pilot light is on during the operation of the clothes dryer for the representative average use cycle for clothes dryers (416 cycles per year)

GEF as defined in 4.3

4.5 *Total per-cycle gas dryer gas energy consumption expressed in Btu's.* Calculate the total gas dryer energy consumption per cycle, E_g, expressed in Btu's per cycle and defined as:

$E_g=E_{gg}+E_{up}$

E_{gg} as defined in 4.3

E_{up} as defined in 4.4

4.6 *Total per-cycle gas dryer energy consumption expressed in kilowatt-hours.* Calculate the total gas dryer energy consumption per cycle, E_{cg}, expressed in kilowatt-hours per cycle and defined as:

$E_{cg}=E_{ge}+(E_g/3412\ Btu/k\ Wh)$

E_{ge} as defined in 4.2

E_g as defined in 4.5

[46 FR 27326, May 19, 1981, as amended at 76 FR 1032, Jan. 6, 2011]

APPENDIX D1 TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF CLOTHES DRYERS

NOTE: Appendix D1 to subpart B of part 430 is informational only. Manufacturers must continue to use appendix D to subpart B of part 430 until compliance with any amended energy conservation standards for clothes dryers at 10 CFR 430.32(h) is required, at which time manufacturers must use appendix D1.

1. DEFINITIONS

1.1 "Active mode" means a mode in which the clothes dryer is connected to a main power source, has been activated and is performing the main function of tumbling the clothing with or without heated or unheated forced air circulation to remove moisture from the clothing, remove wrinkles or prevent wrinkling of the clothing, or both.

1.2 "AHAM" means the Association of Home Appliance Manufacturers.

1.3 "AHAM HLD–1" means the test standard published by the Association of Home Appliance Manufacturers, titled "Household Tumble Type Clothes Dryers" (2009), AHAM HLD–1–2009 (incorporated by reference; see §430.3).

1.4 "Automatic termination control" means a dryer control system with a sensor which monitors either the dryer load temperature or its moisture content and with a controller which automatically terminates the drying process. A mark, detent, or other visual indicator or detent which indicates a preferred automatic termination control setting must be present if the dryer is to be classified as having an "automatic termination control." A mark is a visible single control setting on one or more dryer controls.

1.5 "Bone dry" means a condition of a load of test clothes which has been dried in a dryer at maximum temperature for a minimum of 10 minutes, removed, and weighed before cool down, and then dried again for 10-minute periods until the final weight change of the load is 1 percent or less.

1.6 "Compact" or "compact size" means a clothes dryer with a drum capacity of less than 4.4 cubic feet.

1.7 "Conventional clothes dryer" means a clothes dryer that exhausts the evaporated moisture from the cabinet.

1.8 "Cool down" means that portion of the clothes drying cycle when the added gas or electric heat is terminated and the clothes continue to tumble and dry within the drum.

1.9 "Cycle" means a sequence of operation of a clothes dryer which performs a clothes drying operation, and may include variations or combinations of the functions of heating, tumbling, and drying.

1.10 "Drum capacity" means the volume of the drying drum in cubic feet.

1.11 "IEC 62301" means the test standard published by the International Electrotechnical Commission ("IEC"), titled "Household electrical appliances–Measurement of standby power," Publication 62301 (first edition June 2005) (incorporated by reference; see §430.3).

1.12 "Inactive mode" means a standby mode that facilitates the activation of active mode by remote switch (including remote control), internal sensor, or timer, or that provides continuous status display.

1.13 "Moisture content" means the ratio of the weight of water contained by the test load to the bone-dry weight of the test load, expressed as a percent.

1.14 "Moisture sensing control" means a system which utilizes a moisture sensing element within the dryer drum that monitors the amount of moisture in the clothes and automatically terminates the dryer cycle.

1.15 "Off mode" means a mode in which the clothes dryer is connected to a main power source and is not providing any active or standby mode function, and where the mode may persist for an indefinite time. An indicator that only shows the user that the product is in the off position is included within the classification of an off mode.

1.16 "Standard size" means a clothes dryer with a drum capacity of 4.4 cubic feet or greater.

1.17 "Standby mode" means any product modes where the energy using product is connected to a main power source and offers one or more of the following user-oriented or protective functions which may persist for an indefinite time:

(a) To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, or timer.

(b) Continuous functions, including information or status displays (including clocks) or sensor-based functions. A timer is a continuous clock function (which may or may not be associated with a display) that provides regular scheduled tasks (e.g., switching) and that operates on a continuous basis.

1.18 "Temperature sensing control" means a system which monitors dryer exhaust air temperature and automatically terminates the dryer cycle.

1.19 "Ventless clothes dryer" means a clothes dryer that uses a closed-loop system with an internal condenser to remove the evaporated moisture from the heated air. The moist air is not discharged from the cabinet.

2. Testing Conditions

2.1 *Installation.* Install the clothes dryer in accordance with manufacturer's instructions. For conventional clothes dryers, as defined in 1.7, the dryer exhaust shall be restricted by adding the AHAM exhaust simulator described in 3.3.5.1 of AHAM HLD–1 (incorporated by reference; see §430.3). For ventless clothes dryers, as defined in 1.19, the dryer shall be tested without the AHAM exhaust simulator. Where the manufacturer gives the option to use the dryer both with and without a duct, the dryer shall be tested without the exhaust simulator. All external joints should be taped to avoid air leakage. If the manufacturer gives the option to use a ventless clothes dryer, as defined in 1.19, with or without a condensation box, the dryer shall be tested with the condensation box installed. For ventless clothes dryers, the condenser unit of the dryer must remain in place and not be taken out of the dryer for any reason between tests. For drying testing, disconnect all console lights or other lighting systems on the clothes dryer which do not consume more than 10 watts during the clothes dryer test cycle. For standby and off mode testing, the clothes dryer shall also be installed in accordance with section 5, paragraph 5.2 of IEC 62301 (incorporated by reference; see §430.3). For standby and off mode testing, do not disconnect console lights or other lighting systems.

2.2 *Ambient temperature and humidity.*

2.2.1 For drying testing, maintain the room ambient air temperature at 75 ± 3 °F and the room relative humidity at 50 ± 10 percent relative humidity.

2.2.2 For standby and off mode testing, maintain room ambient air temperature conditions as specified in section 4, paragraph 4.2 of IEC 62301 (incorporated by reference; see §430.3).

2.3 *Energy supply*.

2.3.1 *Electrical supply*. Maintain the electrical supply at the clothes dryer terminal block within 1 percent of 120/240 or 120/208Y or 120 volts as applicable to the particular terminal block wiring system and within 1 percent of the nameplate frequency as specified by the manufacturer. If the dryer has a dual voltage conversion capability, conduct the test at the highest voltage specified by the manufacturer.

2.3.1.1 *Supply voltage waveform*. For the clothes dryer standby mode and off mode testing, maintain the electrical supply voltage waveform indicated in section 4, paragraph 4.4 of IEC 62301 (incorporated by reference; see §430.3).

2.3.2 *Gas supply*.

2.3.2.1 *Natural gas*. Maintain the gas supply to the clothes dryer immediately ahead of all controls at a pressure of 7 to 10 inches of water column. If the clothes dryer is equipped with a gas appliance pressure regulator for which the manufacturer specifies an outlet pressure, the regulator outlet pressure shall be approximately that recommended by the manufacturer. The hourly Btu rating of the burner shall be maintained within ±5 percent of the rating specified by the manufacturer. The natural gas supplied should have a heating value of approximately 1,025 Btus per standard cubic foot. The actual heating value, H_n2, in Btus per standard cubic foot, for the natural gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using a standard continuous flow calorimeter as described in 2.4.6 or by the purchase of bottled natural gas whose Btu rating is certified to be at least as accurate a rating as could be obtained from measurements with a standard continuous flow calorimeter as described in 2.4.6.

2.3.2.2 *Propane gas*. Maintain the gas supply to the clothes dryer immediately ahead of all controls at a pressure of 11 to 13 inches of water column. If the clothes dryer is equipped with a gas appliance pressure regulator for which the manufacturer specifies an outlet pressure, the regulator outlet pressure shall be approximately that recommended by the manufacturer. The hourly Btu rating of the burner shall be maintained within ±5 percent of the rating specified by the manufacturer. The propane gas supplied should have a heating value of approximately 2,500 Btus per standard cubic foot. The actual heating value, H_p, in Btus per standard cubic foot, for the propane gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using a standard continuous flow calorimeter as described in 2.4.6 or by the purchase of bottled gas whose Btu rating is certified to be at least as accurate a rating as could be obtained from measurement with a standard continuous calorimeter as described in 2.4.6.

2.4 *Instrumentation*. Perform all test measurements using the following instruments as appropriate.

2.4.1 *Weighing scale for test cloth*. The scale shall have a range of 0 to a maximum of 30 pounds with a resolution of at least 0.2 ounces and a maximum error no greater than 0.3 percent of any measured value within the range of 3 to 15 pounds.

2.4.1.2 *Weighing scale for drum capacity measurements*. The scale should have a range of 0 to a maximum of 500 pounds with resolution of 0.50 pounds and a maximum error no greater than 0.5 percent of the measured value.

2.4.2 *Kilowatt-hour meter*. The kilowatt-hour meter shall have a resolution of 0.001 kilowatt-hours and a maximum error no greater than 0.5 percent of the measured value.

2.4.3 *Gas meter*. The gas meter shall have a resolution of 0.001 cubic feet and a maximum error no greater than 0.5 percent of the measured value.

2.4.4 *Dry and wet bulb psychrometer*. The dry and wet bulb psychrometer shall have an error no greater than ±1 °F.

2.4.5 *Temperature*. The temperature sensor shall have an error no greater than ±1 °F.

2.4.6 *Standard Continuous Flow Calorimeter*. The calorimeter shall have an operating range of 750 to 3,500 Btu per cubic feet. The maximum error of the basic calorimeter shall be no greater than 0.2 percent of the actual heating value of the gas used in the test. The indicator readout shall have a maximum error no greater than 0.5 percent of the measured value within the operating range and a resolution of 0.2 percent of the full-scale reading of the indicator instrument.

2.4.7 *Standby mode and off mode watt meter*. The watt meter used to measure standby mode and off mode power consumption of the clothes dryer shall have the resolution specified in section 4, paragraph 4.5 of IEC 62301 (incorporated by reference; see §430.3). The watt meter shall also be able to record a "true" average power as specified in section 5, paragraph 5.3.2(a) of IEC 62301.

2.5 *Lint trap*. Clean the lint trap thoroughly before each test run.

2.6 *Test Clothes*.

2.6.1 *Energy test cloth*. The energy test cloth shall be clean and consist of the following:

(a) Pure finished bleached cloth, made with a momie or granite weave, which is a blended fabric of 50-percent cotton and 50-percent polyester and weighs within +10 percent of 5.75 ounces per square yard after test cloth preconditioning, and has 65 ends on the warp and 57 picks on the fill. The individual warp and fill yarns are a blend of 50-percent cotton and 50-percent polyester fibers.

(b) Cloth material that is 24 inches by 36 inches and has been hemmed to 22 inches by 34 inches before washing. The maximum shrinkage after five washes shall not be more than 4 percent on the length and width.

(c) The number of test runs on the same energy test cloth shall not exceed 25 runs.

2.6.2 *Energy stuffer cloths.* The energy stuffer cloths shall be made from energy test cloth material, and shall consist of pieces of material that are 12 inches by 12 inches and have been hemmed to 10 inches by 10 inches before washing. The maximum shrinkage after five washes shall not be more than 4 percent on the length and width. The number of test runs on the same energy stuffer cloth shall not exceed 25 runs after test cloth preconditioning.

2.6.3 *Test Cloth Preconditioning.*

A new test cloth load and energy stuffer cloths shall be treated as follows:

(1) Bone dry the load to a weight change of ± 1 percent, or less, as prescribed in section 1.5.

(2) Place the test cloth load in a standard clothes washer set at the maximum water fill level. Wash the load for 10 minutes in soft water (17 parts per million hardness or less), using 60.8 grams of AHAM standard test detergent Formula 3. Wash water temperature is to be controlled at 140 ° ± 5 °F (60 ° ± 2.7 °C). Rinse water temperature is to be controlled at 100 ° ± 5 °F (37.7 ± 2.7 °C).

(3) Rinse the load again at the same water temperature.

(4) Bone dry the load as prescribed in section 1.5 and weigh the load.

(5) This procedure is repeated until there is a weight change of 1 percent or less.

(6) A final cycle is to be a hot water wash with no detergent, followed by two warm water rinses.

2.7 *Test loads.*

2.7.1 *Compact size dryer load.* Prepare a bone-dry test load of energy cloths which weighs 3.00 pounds ±.03 pounds. Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths, with no more than five stuffer cloths per load. Dampen the load by agitating it in water whose temperature is 60 °F ± 5 °F and consists of 0 to 17 parts per million hardness for approximately 2 minutes in order to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 54.0–61.0 percent of the bone-dry weight of the test load.

2.7.2 *Standard size dryer load.* Prepare a bone-dry test load of energy cloths which weighs 8.45 pounds ±.085 pounds. Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths, with no more than five stuffer cloths per load. Dampen the load by agitating it in water whose temperature is 60 °F ± 5 °F and consists of 0 to 17 parts per million hardness for approximately 2 minutes in order to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 54.0–61.0 percent of the bone-dry weight of the test load.

2.7.3 *Method of loading.* Load the energy test cloths by grasping them in the center, shaking them to hang loosely, and then dropping them in the dryer at random.

2.8 *Clothes dryer preconditioning.*

2.8.1 *Conventional clothes dryers.* For conventional clothes dryers, before any test cycle, operate the dryer without a test load in the non-heat mode for 15 minutes or until the discharge air temperature is varying less than 1 °F for 10 minutes—whichever is longer—in the test installation location with the ambient conditions within the specified test condition tolerances of 2.2.

2.8.2 *Ventless clothes dryers.* For ventless clothes dryers, before any test cycle, the steady-state machine temperature must be equal to ambient room temperature described in 2.2.1. This may be done by leaving the machine at ambient room conditions for at least 12 hours between tests.

3. TEST PROCEDURES AND MEASUREMENTS

3.1 *Drum Capacity.* Measure the drum capacity by sealing all openings in the drum except the loading port with a plastic bag, and ensuring that all corners and depressions are filled and that there are no extrusions of the plastic bag through the opening in the drum. Support the dryer's rear drum surface on a platform scale to prevent deflection of the drum surface, and record the weight of the empty dryer. Fill the drum with water to a level determined by the intersection of the door plane and the loading port. Record the temperature of the water and then the weight of the dryer with the added water and then determine the mass of the water in pounds. Add or subtract the appropriate volume depending on whether or not the plastic bag protrudes into the drum interior. The drum capacity is calculated as follows:

$C = w/d$

C = capacity in cubic feet.

w = weight of water in pounds.

d = density of water at the measured temperature in pounds per cubic feet.

3.2 *Dryer Loading.* Load the dryer as specified in 2.7.

3.3 *Test cycle* Operate the clothes dryer at the maximum temperature setting and, if equipped with a timer, at the maximum time setting and dry the load until the moisture content of the test load is between 2.5 and 5 percent of the bone-dry weight of the test load, but do not permit the dryer to advance into cool down. If required, reset the timer or automatic dry control. If the dryer automatically stops during a cycle because the condensation box is full of water, the test is stopped, and the test run is invalid, in which case the condensation box shall be emptied and the test re-run from the beginning. For ventless dryers, as defined in 1.19, during the time between two cycles, the door of the dryer shall be closed except for loading (and unloading).

3.4 *Data recording*. Record for each test cycle:

3.4.1 Bone-dry weight of the test load described in 2.7.

3.4.2 Moisture content of the wet test load before the test, as described in 2.7.

3.4.3 Moisture content of the dry test load obtained after the test described in 3.3.

3.4.4 Test room conditions, temperature, and percent relative humidity described in 2.2.1.

3.4.5 For electric dryers—the total kilowatt-hours of electric energy, E_t, consumed during the test described in 3.3.

3.4.6 For gas dryers:

3.4.6.1 Total kilowatt-hours of electrical energy, E_{te}, consumed during the test described in 3.3.

3.4.6.2 Cubic feet of gas per cycle, E_{tg}, consumed during the test described in 3.3.

3.4.6.3 Correct the gas heating value, GEF, as measured in 2.3.2.1 and 2.3.2.2, to standard pressure and temperature conditions in accordance with U.S. Bureau of Standards, circular C417, 1938.

3.5 *Test for automatic termination field use factor*. The field use factor for automatic termination can be claimed for those dryers which meet the requirements for automatic termination control, defined in 1.4.

3.6 *Standby mode and off mode power*. Establish the testing conditions set forth in Section 2 "Testing Conditions" of this appendix, omitting the requirement to disconnect all console light or other lighting systems on the clothes dryer that do not consume more than 10 watts during the clothes dryer test cycle in section 2.1. If the clothes dryer waits in a higher power state at the start of standby mode or off mode before dropping to a lower power state, as discussed in section 5, paragraph 5.1, note 1 of IEC 62301 (incorporated by reference; see §430.3),wait until the clothes dryer passes into the lower power state before starting the measurement. Follow the test procedure specified in section 5, paragraph 5.3 of IEC 62301 for testing in each possible mode as described in 3.6.1 and 3.6.2, except allow the product to stabilize for 30 to 40 minutes and use an energy use measurement period of 10 minutes. For units in which power varies over a cycle, as described in section 5, paragraph 5.3.2 of IEC 62301, use the average power approach described in paragraph 5.3.2(a) of IEC 62301, except allow the product to stabilize for 30 to 40 minutes and use an energy use measurement period not less than 10 minutes.

3.6.1 If a clothes dryer has an inactive mode, as defined in 1.12, measure and record the average inactive mode power of the clothes dryer, P_{IA}, in watts.

3.6.2 If a clothes dryer has an off mode, as defined in 1.15, measure and record the average off mode power of the clothes dryer, P_{OFF}, in watts.

4. CALCULATION OF DERIVED RESULTS FROM TEST MEASUREMENTS

4.1 *Total Per-cycle electric dryer energy consumption*. Calculate the total electric dryer energy consumption per cycle, E_{ce}, expressed in kilowatt-hours per cycle and defined as:

$E_{ce} = [53.5/(W_w - W_d)] \times E_{tt} \times \text{field use}$,

Where:

53.5 = an experimentally established value for the percent reduction in the moisture content of the test load during a laboratory test cycle expressed as a percent.

field use = field use factor.

= 1.18 for clothes dryers with time termination control systems only without any automatic termination control functions.

= 1.04 clothes dryers with automatic control systems that meet the requirements of the definition for automatic control systems in 1.4, 1.14 and 1.18, including those that also have a supplementary timer control, or that may also be manually controlled.

W_w = the moisture content of the wet test load as recorded in 3.4.2.

W_d = the moisture content of the dry test load as recorded in 3.4.3.

4.2 *Per-cycle gas dryer electrical energy consumption*. Calculate the gas dryer electrical energy consumption per cycle, E_{ge}, expressed in kilowatt-hours per cycle and defined as:

$E_{ge} = [53.5/(W_w - W_d)] \times E_{te} \times \text{field use}$,

Where:

E_{te} = the energy recorded in 3.4.6.1 field use, 53.5, W_w, W_d as defined in 4.1.

4.3 *Per-cycle gas dryer gas energy consumption*. Calculate the gas dryer gas energy consumption per cycle, E_{ge}, expressed in Btus per cycle as defined as:

$E_{gg} = [53.5/(W_w - W_d)] \times E_{tg} \times \text{field use} \times \text{GEF}$

Where:

E_{tg} = the energy recorded in 3.4.6.2

GEF = corrected gas heat value (Btu per cubic feet) as defined in 3.4.6.3, field use, 53.5, W_w, W_d as defined in 4.1.

4.4 *Total per-cycle gas dryer energy consumption expressed in kilowatt-hours*. Calculate the total gas dryer energy consumption per cycle, E_{cg}, expressed in kilowatt-hours per cycle and defined as:

$E_{cg} = E_{ge} + (E_{gg}/3412 \text{ Btu/kWh})$

Where:

E_{ge} as defined in 4.2
E_{gg} as defined in 4.3

4.5 *Per-cycle standby mode and off mode energy consumption.* Calculate the dryer inactive mode and off mode energy consumption per cycle, E_{TSO}, expressed in kWh per cycle and defined as:

$E_{TSO} = [(P_{IA} \times S_{IA}) + (P_{OFF} \times S_{OFF})] \times K/283$

Where:

P_{IA} = dryer inactive mode power, in watts, as measured in section 3.6.1;
P_{OFF} = dryer off mode power, in watts, as measured in section 3.6.2.
If the clothes dryer has both inactive mode and off mode, S_{IA} and S_{OFF} both equal 8,620 ÷ 2 = 4,310, where 8,620 is the total inactive and off mode annual hours;
If the clothes dryer has an inactive mode but no off mode, the inactive mode annual hours, S_{IA}, is equal to 8,620 and the off mode annual hours, S_{OFF}, is equal to 0;
If the clothes dryer has an off mode but no inactive mode, S_{IA} is equal to 0 and S_{OFF} is equal to 8,620

Where:

K = 0.001 kWh/Wh conversion factor for watt-hours to kilowatt-hours; and
283 = representative average number of clothes dryer cycles in a year.

4.6 *Per-cycle combined total energy consumption expressed in kilowatt-hours.* Calculate the per-cycle combined total energy consumption, $E_{CC,}$ expressed in kilowatt-hours per cycle and defined for an electric clothes dryer as:

$E_{CC} = E_{ce} + E_{TSO}$

Where:

E_{ce} = the energy recorded in 4.1, and
E_{TSO} = the energy recorded in 4.7, and defined for a gas clothes dryer as:
$E_{CC} = E_{cg} + E_{TSO}$

Where:

E_{cg} = the energy recorded in 4.4, and
E_{TSO} = the energy recorded in 4.7.

4.7 *Energy Factor in pounds per kilowatt-hour.* Calculate the energy factor, EF, expressed in pounds per kilowatt-hour and defined for an electric clothes dryer as:

$EF = W_{bonedry}/E_{ce}$

Where:

$W_{bonedry}$ = the bone dry test load weight recorded in 3.4.1, and
E_{ce} = the energy recorded in 4.1, and

and defined for a gas clothes dryer as:

$EF = W_{bonedry}/E_{cg}$

Where:

$W_{bonedry}$ = the bone dry test load weight recorded in 3.4.1, and
E_{cg} = the energy recorded in 4.4,

4.8 *Combined Energy Factor in pounds per kilowatt-hour.* Calculate the combined energy factor, CEF, expressed in pounds per kilowatt-hour and defined as:

$CEF = W_{bonedry}/E_{CC}$

Where:

$W_{bonedry}$ = the bone dry test load weight 3.4.1, and
E_{CC} = the energy recorded in 4.6

[76 FR 1032, Jan. 6, 2011]

Appendix E to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Water Heaters

1. Definitions

1.1 *Cut-in* means the time when or water temperature at which a water heater control or thermostat acts to increase the energy or fuel input to the heating elements, compressor, or burner.

1.2 *Cut-out* means the time when or water temperature at which a water heater control or thermostat acts to reduce to a minimum the energy or fuel input to the heating elements, compressor, or burner.

1.3 *Design Power Rating* means the nominal power rating that a water heater manufacturer assigns to a particular design of water heater, expressed in kilowatts or Btu (kJ) per hour as appropriate.

1.4 *Energy Factor* means a measure of water heater overall efficiency.

1.5 *First-Hour Rating* means an estimate of the maximum volume of "hot" water that a storage-type water heater can supply within an hour that begins with the water heater fully heated (i.e., with all thermostats satisfied). It is a function of both the storage volume and the recovery rate.

1.6 *Heat Trap* means a device which can be integrally connected or independently attached to the hot and/or cold water pipe connections of a water heater such that the device will develop a thermal or mechanical seal to minimize the recirculation of water due to thermal convection between the water heater tank and its connecting pipes.

1.7 *Instantaneous Water Heaters*

1.7.1 *Electric Instantaneous Water Heater* Reserved.

1.7.2 *Gas Instantaneous Water Heater* means a water heater that uses gas as the energy source, initiates heating based on sensing water flow, is designed to deliver water at a controlled temperature of less than 180 °F (82 °C), has an input greater than 50,000 Btu/h (53 MJ/h) but less than 200,000 Btu/h (210 MJ/h), and has a manufacturer's specified storage capacity of less than 2 gallons (7.6 liters). The unit may use a fixed or variable burner input.

1.8 *Maximum gpm (L/min) Rating* means the maximum gallons per minute (liters per minute) of hot water that can be supplied by an instantaneous water heater while maintaining a nominal temperature rise of 77 °F (42.8 °C) during steady state operation.

1.9 *Rated Storage Volume* means the water storage capacity of a water heater, in gallons (liters), as specified by the manufacturer.

1.10 *Recovery Efficiency* means the ratio of energy delivered to the water to the energy content of the fuel consumed by the water heater.

1.11 *Standby* means the time during which water is not being withdrawn from the water heater. There are two standby time intervals used within this test procedure: $\tau_{stby,1}$ represents the elapsed time between the time at which the maximum mean tank temperature is observed after the sixth draw and subsequent recovery and the end of the 24-hour test; $\tau_{stby,2}$ represents the total time during the 24-hour simulated use test when water is not being withdrawn from the water heater.

1.12 *Storage-type Water Heaters*

1.12.1 *Electric Storage-type Water Heater* means a water heater that uses electricity as the energy source, is designed to heat and store water at a thermostatically controlled temperature of less than 180 °F (82 °C), has a nominal input of 12 kilowatts (40,956 Btu/h) or less, and has a rated storage capacity of not less than 20 gallons (76 liters) nor more than 120 gallons (450 liters).

1.12.2 *Gas Storage-type Water Heater* means a water heater that uses gas as the energy source, is designed to heat and store water at a thermostatically controlled temperature of less than 180 °F (82 °C), has a nominal input of 75,000 Btu (79 MJ) per hour or less, and has a rated storage capacity of not less than 20 gallons (76 liters) nor more than 100 gallons (380 liters).

1.12.3 *Heat Pump Water Heater* means a water heater that uses electricity as the energy source, is designed to heat and store water at a thermostatically controlled temperature of less than 180 °F (82 °C), has a maximum current rating of 24 amperes (including the compressor and all auxiliary equipment such as fans, pumps, controls, and, if on the same circuit, any resistive elements) for an input voltage of 250 volts or less, and, if the tank is supplied, has a manufacturer's rated storage capacity of 120 gallons (450 liters) or less. Resistive elements used to provide supplemental heating may use the same circuit as the compressor if (1) an interlocking mechanism prevents concurrent compressor operation and resistive heating or (2) concurrent operation does not result in the maximum current rating of 24 amperes being exceeded. Otherwise, the resistive elements and the heat pump components must use separate circuits. A heat pump water heater may be sold by the manufacturer with or without a storage tank.

a. Heat Pump Water Heater with Storage Tank means an air-to-water heat pump sold by the manufacturer with an insulated storage tank as a packaged unit. The tank and heat pump can be an integral unit or they can be separated.

b. Heat Pump Water Heater without Storage Tank (also called Add-on Heat Pump Water Heater) means an air-to-water heat pump designed for use with a storage-type water heater or a storage tank that is not specified or supplied by the manufacturer.

1.12.4 *Oil Storage-type Water Heater* means a water heater that uses oil as the energy source, is designed to heat and store water at a thermostatically controlled temperature of less than 180 °F (82 °C), has a nominal energy input of 105,000 Btu/h (110 MJ/h) or less, and has a manufacturer's rated storage capacity of 50 gallons (190 liters) or less.

1.12.5 *Storage-type Water Heater of More than 2 Gallons (7.6 Liters) and Less than 20 Gallons (76 Liters)*. Reserved.

1.13 *ASHRAE Standard 41.1–86* means the standard published in 1986 by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., and titled Standard Measurement Guide: Section on Temperature Measurements.

1.14 *ASTM–D–2156–80* means the test standard published in 1980 by the American Society for Testing and Measurements and titled "Smoke Density in Flue Gases from Burning Distillate Fuels, Test Method for".

1.15 *Symbol Usage* The following identity relationships are provided to help clarify the symbology used throughout this procedure:

C_p specific heat capacity of water

E_{annual} annual energy consumption of a water heater

E_f energy factor of a water heater

F_{hr} first-hour rating of a storage-type water heater

F_{max} maximum gpm (L/min) rating of an instantaneous water heater rated at a temperature rise of 77 °F (42.8 °C) across the heater

i a subscript to indicate an ith draw during a test

M_i mass of water removed during the ith draw (i=1 to 6) of the 24-hr simulated use test

M^*_i for storage-type water heaters, mass of water removed during the ith draw (i=1 to n) during the first-hour rating test

M_{10m} for instantaneous water heaters, mass of water removed continuously during a 10-minute interval in the maximum gpm (L/min) rating test

n for storage-type water heaters, total number of draws during the first-hour rating test

Q total fossil fuel and/or electric energy consumed during the entire 24-hr simulated use test

Q_d daily water heating energy consumption adjusted for net change in internal energy

Q_{da} adjusted daily water heating energy consumption with adjustment for variation of tank to ambient air temperature difference from nominal value

Q_{dm} overall adjusted daily water heating energy consumption including Q_{da} and Q_{HWD}

Q_{hr} hourly standby losses

Q_{HW} daily energy consumption to heat water over the measured average temperature rise across the water heater

Q_{HWD} adjustment to daily energy consumption, Q_{hw}, due to variation of the temperature rise across the water heater not equal to the nominal value of 77 °F (42.8 °C)

Q_r energy consumption of fossil fuel or heat pump water heaters between thermostat (or burner) cut-out prior to the first draw and cut-out following the first draw of the 24-hr simulated use test

$Q_{r,\ max}$ energy consumption of a modulating instantaneous water heater between cut-out (burner) prior to the first draw and cut-out following the first draw of the 24-hr simulated use test

$Q_{r,\ min}$ energy consumption of a modulating instantaneous water heater from immediately prior to the fourth draw to burner cut-out following the fourth draw of the 24-hr simulated use test

Q_{stby} total energy consumed by the water heater during the standby time interval $\tau_{stby,\ 1}$

Q_{su} total fossil fueled and/or electric energy consumed from the beginning of the first draw to the thermostat (or burner) cut-out following the completion of the sixth draw during the 24-hr simulated use test

T_{min} for modulating instantaneous water heaters, steady state outlet water temperature at the minimum fuel input rate

$\bar{T}_0$ mean tank temperature at the beginning of the 24-hr simulated use test

$\bar{T}_{24}$ mean tank temperature at the end of the 24-hr simulated use test

$\bar{T}_{a,\ stby}$ average ambient air temperature during standby periods of the 24-hr use test

$\bar{T}_{del}$ for instantaneous water heaters, average outlet water temperature during a 10-minute continuous draw interval in the maximum gpm (L/min) rating test

$\bar{T}_{del,\ i}$ average outlet water temperature during the *i*th draw of the 24-hr simulated use test

$\bar{T}_{in}$ for instantaneous water heaters, average inlet water temperature during a 10-minute continuous draw interval in the maximum gpm (L/min) rating test

$\bar{T}_{in,\ i}$ average inlet water temperature during the *i*th draw of the 24-hr simulated use test

$\bar{T}_{max,\ 1}$ maximum measured mean tank temperature after cut-out following the first draw of the 24-hr simulated use test

$\bar{T}_{stby}$ average storage tank temperature during the standby period $\tau_{stby,\ 2}$ of the 24-hr use test

$\bar{T}_{su}$ maximum measured mean tank temperature after cut-out following the sixth draw of the 24-hr simulated use test

$\bar{T}_{t,\ stby}$ average storage tank temperature during the standby period τ_{stby}, 1 of the 24-hr use test

$\bar{T}^*_{del,\ i}$ for storage-type water heaters, average outlet water temperature during the *i*th draw (i=1 to n) of the first-hour rating test

$T^*_{max,\ i}$ for storage-type water heaters, maximum outlet water temperature observed during the *i*th draw (i=1 to n) of the first-hour rating test

$T^*_{min,\ i}$ for storage-type water heaters, minimum outlet water temperature to terminate the *i*th draw during the first-hour rating test

UA standby loss coefficient of a storage-type water heater

V_i volume of water removed during the *i*th draw (i=1 to 6) of the 24-hr simulated use test

V^*_i volume of water removed during the *i*th draw (i=1 to n) during the first-hour rating test

V_{10m} for instantaneous water heaters, volume of water removed continuously during a 10-minute interval in the maximum gpm (L/min) rating test

V_{max} steady state water flow rate of an instantaneous water heater at the rated input to give a discharge temperature of 135 °F ±5 °F (57.2 °C ±2.8 °C)

V_{min} steady state water flow rate of a modulating instantaneous water heater at the minimum input to give a discharge temperature of T_{min} up to 135 °F ±5 °F (57.2 °C ±2.8 °C)

V_{st} measured storage volume of the storage tank

W_f weight of storage tank when completely filled with water

W_t tare weight of storage tank when completely empty of water

η_r recovery efficiency

ρ density of water

$\tau_{stby,\ 1}$ elapsed time between the time the maximum mean tank temperature is observed after the sixth draw and the end of the 24-hr simulated use test

$\tau_{stby,\ 2}$ overall standby periods when no water is withdrawn during the 24-hr simulated use test

1.16 *Tabletop water heater* means a water heater in a rectangular box enclosure designed to slide into a kitchen countertop space with typical dimensions of 36 inches high, 25 inches deep and 24 inches wide.

2. Test Conditions

2.1 *Installation Requirements*. Tests shall be performed with the water heater and instrumentation installed in accordance with Section 4 of this appendix.

2.2 *Ambient Air Temperature*. The ambient air temperature shall be maintained between

65.0 °F and 70.0 °F (18.3 °C and 21.1 °C) on a continuous basis. For heat pump water heaters, the dry bulb temperature shall be maintained at 67.5 °F ±1 °F (19.7 °C ±0.6 °C) and, in addition, the relative humidity shall be maintained between 49% and 51%.

2.3 *Supply Water Temperature*. The temperature of the water being supplied to the water heater shall be maintained at 58 °F ±2 °F (14.4 °C ±1.1 °C) throughout the test.

2.4 *Storage Tank Temperature*. The average temperature of the water within the storage tank shall be set to 135 °F ±5 °F (57.2 °C ±2.8 °C).

2.5 *Supply Water Pressure*. During the test when water is not being withdrawn, the supply pressure shall be maintained between 40 psig (275 kPa) and the maximum allowable pressure specified by the water heater manufacturer.

2.6 *Electrical and/or Fossil Fuel Supply*.

2.6.1 *Electrical*. Maintain the electrical supply voltage to within ±1% of the center of the voltage range specified by the water heater and/or heat pump manufacturer.

2.6.2 *Natural Gas*. Maintain the supply pressure in accordance with the manufacturer's specifications. If the supply pressure is not specified, maintain a supply pressure of 7–10 inches of water column (1.7–2.5 kPa). If the water heater is equipped with a gas appliance pressure regulator, the regulator outlet pressure shall be within ±10% of the manufacturer's specified manifold pressure. For all tests, use natural gas having a heating value of approximately 1,025 Btu per standard cubic foot (38,190 kJ per standard cubic meter).

2.6.3 *Propane Gas*. Maintain the supply pressure in accordance with the manufacturer's specifications. If the supply pressure is not specified, maintain a supply pressure of 11–13 inches of water column (2.7–3.2 kPa). If the water heater is equipped with a gas appliance pressure regulator, the regulator outlet pressure shall be within ±10% of the manufacturer's specified manifold pressure. For all tests, use propane gas with a heating value of approximately 2,500 Btu per standard cubic foot (93,147 kJ per standard cubic meter).

2.6.4 *Fuel Oil Supply*. Maintain an uninterrupted supply of fuel oil. Use fuel oil having a heating value of approximately 138,700 Btu per gallon (38,660 kJ per liter).

3. Instrumentation

3.1 *Pressure Measurements*. Pressure-measuring instruments shall have an error no greater than the following values:

Item measured	Instrument accuracy	Instrument precision
Gas pressure	±0.1 inch of water column (±0.025 kPa)	±0.05 inch of water column (±0.012 kPa).
Atmospheric pressure	±0.1 inch of mercury column (±0.34 kPa)	±0.05 inch of mercury column (±0.17 kPa).
Water pressure	±1.0 pounds per square inch (±6.9 kPa)	±0.50 pounds per square inch (±3.45 kPa).

3.2 *Temperature Measurement*

3.2.1 *Measurement*. Temperature measurements shall be made in accordance with the Standard Measurement Guide: Section on Temperature Measurements, ASHRAE Standard 41.1–86.

3.2.2 *Accuracy and Precision*. The accuracy and precision of the instruments, including their associated readout devices, shall be within the following limits:

Item measured	Instrument accuracy	Instrument precision
Air dry bulb temperature	±0.2 °F (±0.1 °C)	±0.1 °F (±0.06 °C)
Air wet bulb temperature	±0.2 °F (±0.1 °C)	±0.1 °F (±0.06 °C)
Inlet and outlet water temperatures	±0.2 °F (±0.1 °C)	±0.1 °F (±0.06 °C)
Storage tank temperatures	±0.5 °F (±0.3 °C)	±0.25 °F (±0.14 °C)

3.2.3 *Scale Division*. In no case shall the smallest scale division of the instrument or instrument system exceed 2 times the specified precision.

3.2.4 *Temperature Difference*. Temperature difference between the entering and leaving water may be measured with any of the following:

a. A thermopile
b. Calibrated resistance thermometers
c. Precision thermometers
d. Calibrated thermistors
e. Calibrated thermocouples
f. Quartz thermometers

3.2.5 *Thermopile Construction*. If a thermopile is used, it shall be made from calibrated thermocouple wire taken from a single spool. Extension wires to the recording device shall also be made from that same spool.

3.2.6 *Time Constant*. The time constant of the instruments used to measure the inlet and outlet water temperatures shall be no greater than 5 seconds.

3.3 *Liquid Flow Rate Measurement*. The accuracy of the liquid flow rate measurement, using the calibration if furnished, shall be equal to or less than ±1% of the measured value in mass units per unit time.

3.4 *Electric Energy*. The electrical energy used shall be measured with an instrument and associated readout device that is accurate within ±1% of the reading.

3.5 *Fossil Fuels*. The quantity of fuel used by the water heater shall be measured with an instrument and associated readout device that is accurate within ±1% of the reading.

3.6 *Mass Measurements*. For mass measurements greater than or equal to 10 pounds (4.5 kg), a scale that is accurate within ±1% of the reading shall be used to make the measurement. For mass measurements less than 10 pounds (4.5 kg), the scale shall provide a measurement that is accurate within ±0.1 pound (0.045 kg).

3.7 *Heating Value*. The higher heating value of the natural gas, propane, or fuel oil shall be measured with an instrument and associated readout device that is accurate within ±1% of the reading. The heating value of natural gas and propane must be corrected for local temperature and pressure conditions.

3.8 *Time*. The elapsed time measurements shall be measured with an instrument that is accurate within ±0.5 seconds per hour.

3.9 *Volume*. Volume measurements shall be measured with an accuracy of ±2% of the total volume.

4. Installation

4.1 *Water Heater Mounting*. A water heater designed to be freestanding shall be placed on a ¾ inch (2 cm) thick plywood platform supported by three 2 × 4 inch (5 cm × 10 cm) runners. If the water heater is not approved for installation on combustible flooring, suitable non-combustible material shall be placed between the water heater and the platform. Counter-top water heaters shall be placed against a simulated wall section. Wall-mounted water heaters shall be supported on a simulated wall in accordance with the manufacturer-published installation instructions. When a simulated wall is used, the recommended construction is 2 × 4 inch (5 cm × 10 cm) studs, faced with ¾ inch (2 cm) plywood. For heat pump water heaters that are supplied with a storage tank, the two components, if not delivered as a single package, shall be connected in accordance with the manufacturer-published installation instructions and the overall system shall be placed on the above-described plywood platform. If installation instructions are not provided by the heat pump manufacturer, uninsulated 8 foot (2.4 m) long connecting hoses having an inside diameter of ⅝ inch (1.6 cm) shall be used to connect the storage tank and the heat pump water heater. With the exception of using the storage tank described in 4.10, the same requirements shall apply for heat pump water heaters that are supplied without a storage tank from the manufacturer. The testing of the water heater shall occur in an area that is protected from drafts.

4.2 *Water Supply*. Connect the water heater to a water supply capable of delivering water at conditions as specified in Sections 2.3 and 2.5 of this appendix.

4.3 *Water Inlet and Outlet Configuration*. For freestanding water heaters that are taller than 36 inches (91.4 cm), inlet and outlet piping connections shall be configured in a manner consistent with Figures 1 and 2. Inlet and outlet piping connections for wall-mounted water heaters shall be consistent with Figure 3. For freestanding water heaters that are 36 inches or less in height and not supplied as part of a counter-top enclosure (commonly referred to as an under-the-counter model), inlet and outlet piping shall be installed in a manner consistent with Figures 4, 5, and 6. For water heaters that are supplied with a counter-top enclosure, inlet and outlet piping shall be made in a manner consistent with Figures 7A and 7B, respectively. The vertical piping noted in Figures 7A and 7B shall be located (whether inside the enclosure or along the outside in a recessed channel) in accordance with the manufacturer-published installation instructions.

All dimensions noted in Figures 1 through 7 shall be achieved. All piping between the water heater and the inlet and outlet temperature sensors, noted as T_{IN} and T_{OUT} in the figures, shall be Type ''L'' hard copper having the same diameter as the connections on the water heater. Unions may be used to facilitate installation and removal of the piping arrangements. A pressure gauge and diaphragm expansion tank shall be installed in the supply water piping at a location upstream of the inlet temperature sensor. An appropriately rated pressure and temperature relief valve shall be installed on all water heaters at the port specified by the manufacturer. Discharge piping for the relief valve shall be non-metallic. If heat traps, piping insulation, or pressure relief valve insulation are supplied with the water heater, they shall be installed for testing. Except when using a simulated wall, clearance shall be provided such that none of the piping contacts other surfaces in the test room.

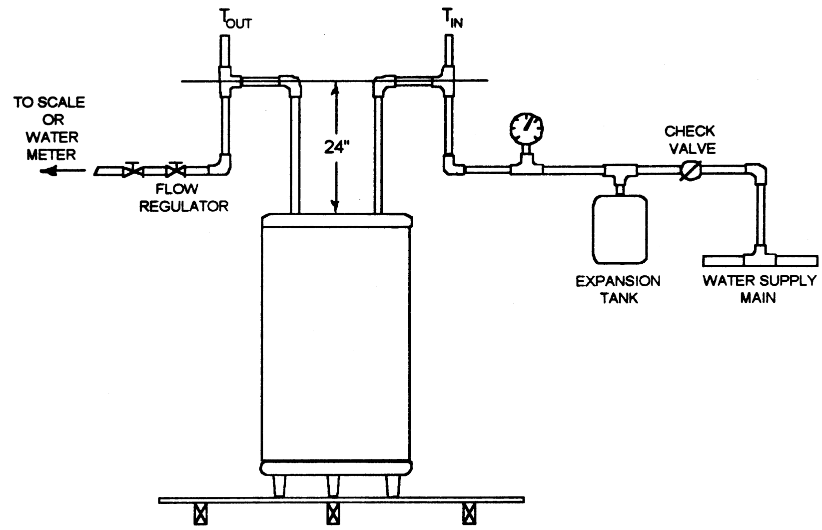


Figure 1.

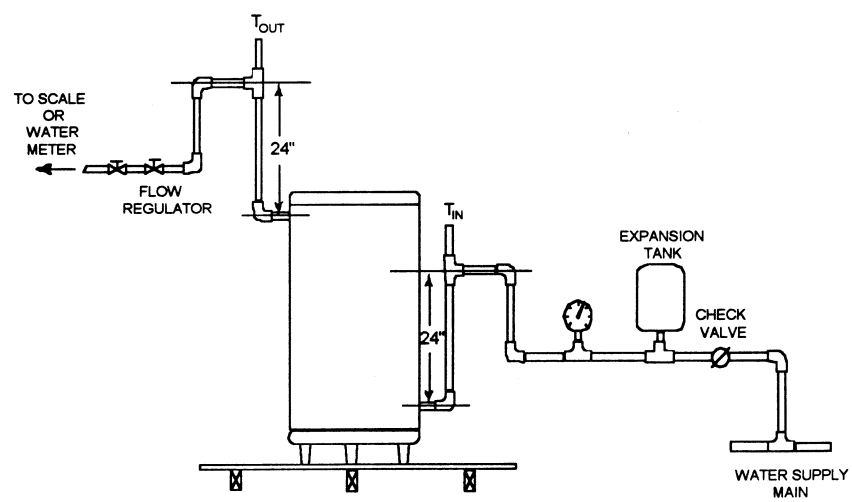


Figure 2.

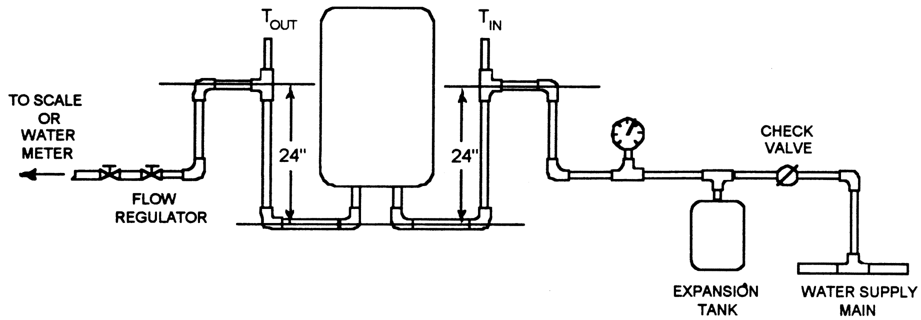


Figure 3.

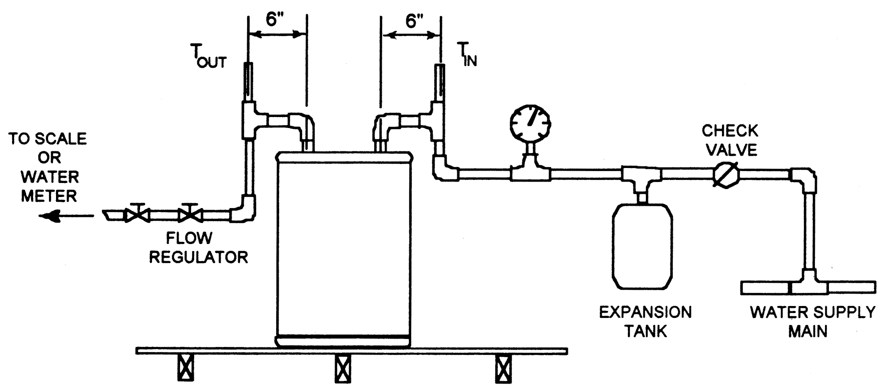


Figure 4.

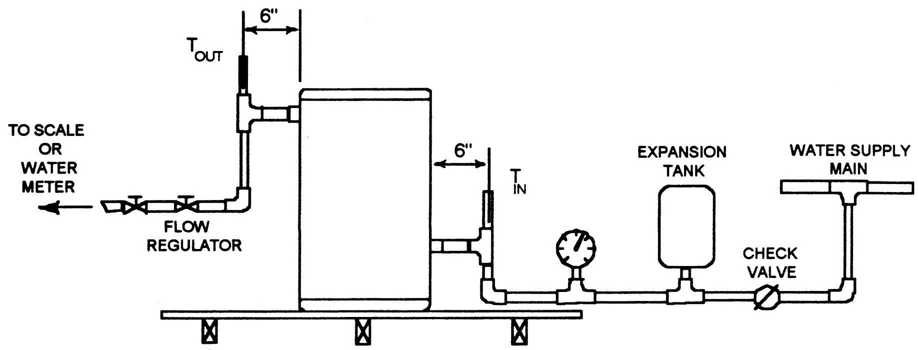


Figure 5.

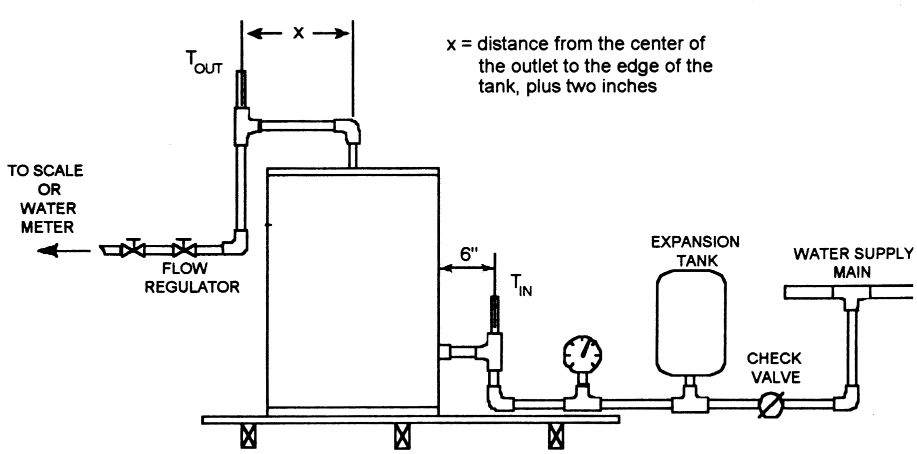


Figure 6.

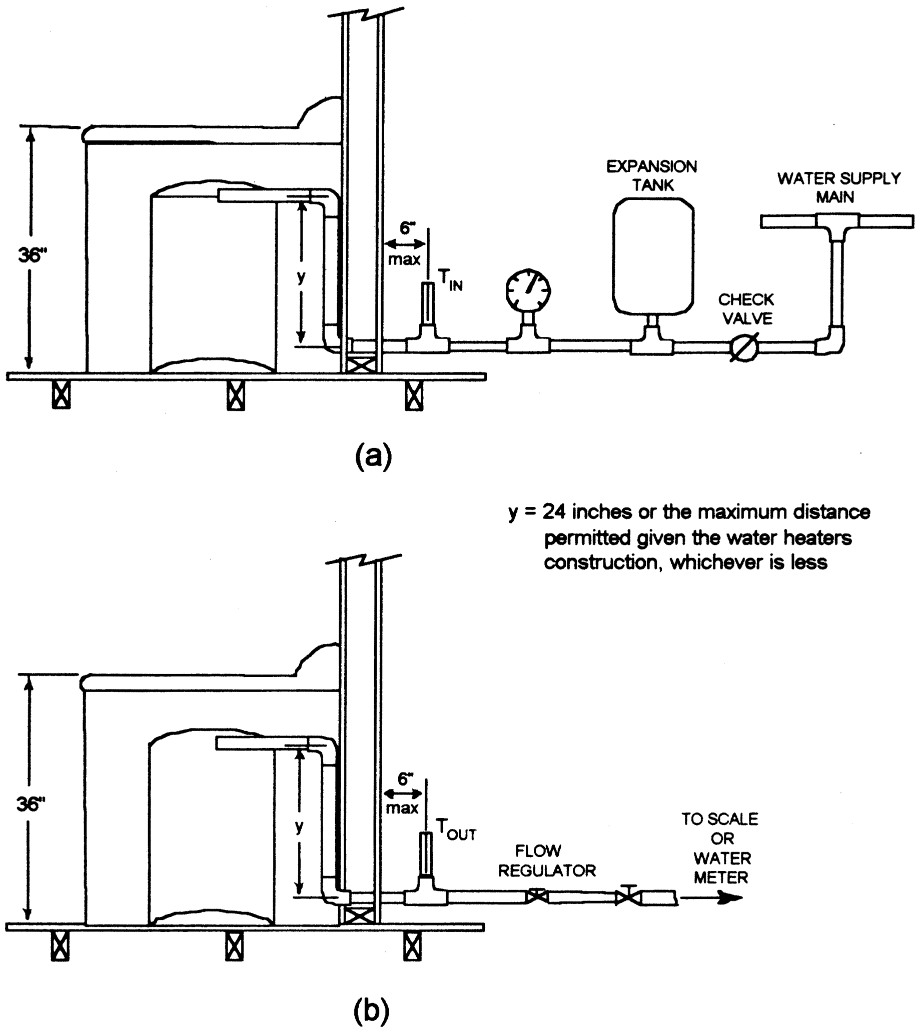


Figure 7.

4.4 *Fuel and/or Electrical Power and Energy Consumption.* Install one or more instruments which measure, as appropriate, the quantity and rate of electrical energy and/or fossil fuel consumption in accordance with Section 3. For heat pump water heaters that use supplemental resistive heating, the electrical energy supplied to the resistive element(s) shall be metered separately from the electrical energy supplied to the entire appliance or to the remaining components (e.g., compressor, fans, pumps, controls).

4.5 *Internal Storage Tank Temperature Measurements.* Install six temperature measurement sensors inside the water heater tank with a vertical distance of at least 4 inches (100 mm) between successive sensors. A temperature sensor shall be positioned at the vertical midpoint of each of the six equal volume nodes within the tank. Nodes designate the equal volumes used to evenly partition the total volume of the tank. As much as is possible, the temperature sensor should be positioned away from any heating elements, anodic protective devices, tank walls, and flue pipe walls. If the tank cannot accommodate six temperature sensors and meet the installation requirements specified above, install the maximum number of sensors which comply with the installation requirements. The temperature sensors shall be installed either through (1) the anodic device opening; (2) the relief valve opening; or (3) the hot water outlet. If installed through the relief valve opening or the hot water outlet, a tee fitting or outlet piping, as applicable, shall be installed as close as possible to its original location. If the relief valve temperature sensor is relocated, and it no longer extends into the top of the tank, a substitute relief valve that has a sensing element that can reach into the tank shall be installed. If the hot water outlet includes a heat trap, the heat trap shall be installed on top of the tee fitting. Added fittings shall be covered with thermal insulation having an R value between 4 and 8 h÷ft$^{2\div}$ °F/Btu (0.7 and 1.4 m$^{2\div}$ °C/W).

4.6 *Ambient Air Temperature Measurement.* Install an ambient air temperature sensor at the vertical mid-point of the water heater and approximately 2 feet (610 mm) from the surface of the water heater. The sensor shall be shielded against radiation.

4.7 *Inlet and Outlet Water Temperature Measurements.* Install temperature sensors in the cold-water inlet pipe and hot-water outlet pipe as shown in Figures 1, 2, 3, 4, 5, 6, 7a and 7b, as applicable.

4.8 *Flow Control.* A valve shall be installed to provide flow as specified in sections 5.1.4.1 for storage tank water heaters and 5.2.1 for instantaneous water heaters.

4.9 *Flue Requirements.*

4.9.1 *Gas-Fired Water Heaters.* Establish a natural draft in the following manner. For gas-fired water heaters with a vertically discharging draft hood outlet, a 5-foot (1.5-meter) vertical vent pipe extension with a diameter equal to the largest flue collar size of the draft hood shall be connected to the draft hood outlet. For gas-fired water heaters with a horizontally discharging draft hood outlet, a 90-degree elbow with a diameter equal to the largest flue collar size of the draft hood shall be connected to the draft hood outlet. A 5-foot (1.5-meter) length of vent pipe shall be connected to the elbow and oriented to discharge vertically upward. Direct vent gas-fired water heaters shall be installed with venting equipment specified in the manufacturer's instructions using the minimum vertical and horizontal lengths of vent pipe recommended by the manufacturer.

4.9.2 *Oil-Fired Water Heaters.* Establish a draft at the flue collar at the value specified in the manufacturer's instructions. Establish the draft by using a sufficient length of vent pipe connected to the water heater flue outlet, and directed vertically upward. For an oil-fired water heater with a horizontally discharging draft hood outlet, a 90-degree elbow with a diameter equal to the largest flue collar size of the draft hood shall be connected to the draft hood outlet. A length of vent pipe sufficient to establish the draft shall be connected to the elbow fitting and oriented to discharge vertically upward. Direct-vent oil-fired water heaters should be installed with venting equipment as specified in the manufacturer's instructions, using the minimum vertical and horizontal lengths of vent pipe recommended by the manufacturer.

4.10 *Heat Pump Water Heater Storage Tank.* The tank to be used for testing a heat pump water heater without a tank supplied by the manufacturer (see Section 1.12.3b) shall be an electric storage-type water heater having a measured volume of 47.0 gallons ±1.0 gallon (178 liters ±3.8 liters); two 4.5 kW heating elements controlled in such a manner as to prevent both elements from operating simultaneously; and an energy factor greater than or equal to the minimum energy conservation standard (as determined in accordance with Section 6.1.7) and less than or equal to the sum of the minimum energy conservation standard and 0.02.

5. Test Procedures

5.1 *Storage-type Water Heaters, Including Heat Pump Water Heaters.*

5.1.1 *Determination of Storage Tank Volume.* Determine the storage capacity, V_{st}, of the water heater under test, in gallons (liters), by subtracting the tare weight—measured while the tank is empty—from the gross weight of the storage tank when completely filled with water (with all air eliminated and line pressure applied as described in section 2.5) and dividing the resulting net weight by the density of water at the measured temperature.

5.1.2 *Setting the Thermostat.*

5.1.2.1 *Single Thermostat Tanks.* Starting with a tank at the supply water temperature, initiate normal operation of the water heater. After cut-out, determine the mean tank temperature every minute until the maximum value is observed. Determine whether this maximum value for the mean tank temperature is within the range of 135 °F±5 °F (57.2 °C±2.8 °C). If not, turn off the water heater, adjust the thermostat, drain and refill the tank with supply water. Then, once again, initiate normal operation of the water heater, and determine the maximum mean tank temperature after cut-out. Repeat this sequence until the maximum mean tank temperature after cut-out is 135 °F±5 °F (57.2 °C±2.8 °C).

5.1.2.2 *Tanks with Two or More Thermostats*. Follow the same sequence as for a single thermostat tank, i.e. start at the supply water temperature, operate normally until cutout. Determine if the thermostat that controls the uppermost heating element yields a maximum water temperature of 135 °F±5 °F (57.2 °C±2.8 °C), as measured by the in-tank sensors that are positioned above the uppermost heating element. If the tank temperature at the thermostat is not within 135 °F±5 °F (57.2 °C±2.8 °C), turn off the water heater, adjust the thermostat, drain and refill the tank with supply water. The thermostat that controls the heating element positioned next highest in the tank shall then be set to yield a maximum water temperature of 135 °F±5 °F (57.2 °C±2.8 °C). This process shall be repeated until the thermostat controlling the lowest element is correctly adjusted. When adjusting the thermostat that controls the lowest element, the maximum mean tank temperature after cut-out, as determined using all the in-tank sensors, shall be 135 °F±5 °F (57.2 °C±2.8 °C). When adjusting all other thermostats, use only the in-tank temperature sensors positioned above the heating element in question to evaluate the maximum water temperature after cut-out.

For heat pump water heaters that control an auxiliary resistive element, the thermostat shall be set in accordance with the manufacturer's installation instructions.

5.1.3 *Power Input Determination*. For all water heaters except electric types having immersed heating elements, initiate normal operation and determine the power input, P, to the main burners (including pilot light power, if any) after 15 minutes of operation. If the water heater is equipped with a gas appliance pressure regulator, the regulator outlet pressure shall be set within ±10% of that recommended by the manufacturer. For oil-fired water heaters the fuel pump pressure shall be within ±10% of the manufacturer's specified pump pressure. All burners shall be adjusted to achieve an hourly Btu (kJ) rating that is within ±2% of the value specified by the manufacturer. For an oil-fired water heater, adjust the burner to give a CO_2 reading recommended by the manufacturer and an hourly Btu (kJ) rating that is within ±2% of that specified by the manufacturer. Smoke in the flue may not exceed No. 1 smoke as measured by the procedure in ASTM–D–2156–80.

5.1.4 *First-Hour Rating Test*.

5.1.4.1 *General*. During hot water draws, remove water at a rate of 3.0±0.25 gallons per minute (11.4±0.95 liters per minute). Collect the water in a container that is large enough to hold the volume removed during an individual draw and suitable for weighing at the termination of each draw. Alternatively, a water meter may be used to directly measure the water volume(s) withdrawn.

5.1.4.2 *Draw Initiation Criteria*. Begin the first-hour rating test by imposing a draw on the storage-type water heater. After completion of this first draw, initiate successive draws based on the following criteria. For gas-and oil-fired water heaters, initiate successive draws when the thermostat acts to reduce the supply of fuel to the main burner. For electric water heaters having a single element or multiple elements that all operate simultaneously, initiate successive draws when the thermostat acts to reduce the electrical input supplied to the element(s). For electric water heaters having two or more elements that do not operate simultaneously, initiate successive draws when the applicable thermostat acts to reduce the electrical input to the element located vertically highest in the storage tank. For heat pump waters heaters that do not use supplemental resistive heating, initiate successive draws immediately after the electrical input to the compressor is reduced by the action of the water heater's thermostat. For heat pump waters heaters that use supplemental resistive heating, initiate successive draws immediately after the electrical input to the compressor or the uppermost resistive element is reduced by the action of the applicable water heater thermostat. This draw initiation criterion for heat pump water heaters that use supplemental resistive heating, however, shall only apply when the water located above the thermostat at cut-out is heated to 135 °F±5 °F (57.2 °C±2.8 °C).

5.1.4.3 *Test Sequence*. Establish normal water heater operation. If the water heater is not presently operating, initiate a draw. The draw may be terminated anytime after cut-in occurs. After cut-out occurs (i.e., all thermostats are satisfied), monitor the internal storage tank temperature sensors described in section 4.5 every minute.

Initiate a draw after a maximum mean tank temperature has been observed following cut-out. Record the time when the draw is initiated and designate it as an elapsed time of zero ($\tau^* = 0$). (The superscript * is used to denote variables pertaining to the first-hour rating test.) Record the outlet water temperature beginning 15 seconds after the draw is initiated and at 5-second intervals thereafter until the draw is terminated. Determine the maximum outlet temperature that occurs during this first draw and record it as $T^*_{max,1}$. For the duration of this first draw and all successive draws, in addition, monitor the inlet temperature to the water heater to ensure that the required 58 °F±2 °F (14.4 °C±1.1 °C) test condition is met. Terminate the hot water draw when the outlet temperature decreases to $T^*_{max,1} - 25$ °F ($T^*_{max,1} - 13.9$ °C). Record this temperature as

$T^*_{min,1}$. Following draw termination, determine the average outlet water temperature and the mass or volume removed during this first draw and record them as $\bar{T}^*_{del,1}$ and M^*_1 or V^*_1, respectively.

Initiate a second and, if applicable, successive draw each time the applicable draw initiation criteria described in section 5.1.4.2 are satisfied. As required for the first draw, record the outlet water temperature 15 seconds after initiating each draw and at 5-second intervals thereafter until the draw is terminated. Determine the maximum outlet temperature that occurs during each draw and record it as $T^*_{max,\ i}$, where the subscript i refers to the draw number. Terminate each hot water draw when the outlet temperature decreases to $T^*_{max,\ i} - 25$ °F ($T^*_{max,\ i} - 13.9$ °C). Record this temperature as $T^*_{min,\ i}$. Calculate and record the average outlet temperature and the mass or volume removed during each draw ($\bar{T}^*_{del,\ i}$ and M^*_i or V^*_i, respectively). Continue this sequence of draw and recovery until one hour has elapsed, then shut off the electrical power and/or fuel supplied to the water heater.

If a draw is occurring at an elapsed time of one hour, continue this draw until the outlet temperature decreases to $T^*_{max,\ n} - 25$ °F ($T^*_{max,\ n} - 13.9$ °C), at which time the draw shall be immediately terminated. (The subscript n shall be used to denote quantities associated with the final draw.) If a draw is not occurring at an elapsed time of one hour, a final draw shall be imposed at one hour. This draw shall be immediately terminated when the outlet temperature first indicates a value less than or equal to the cut-off temperature used for the previous draw ($T^*_{min,\ n-1}$). For cases where the outlet temperature is close to $T^*_{min,\ n-1}$, the final draw shall proceed for a minimum of 30 seconds. If an outlet temperature greater than $T^*_{min,\ n-1}$ is not measured within 30 seconds, the draw shall be immediately terminated and zero additional credit shall be given towards first-hour rating (i.e., $M^*_n = 0$ or $V^*_n = 0$). After the final draw is terminated, calculate and record the average outlet temperature and the mass or volume removed during the draw ($\bar{T}^*_{del,\ n}$ and M^*_n or V^*_n, respectively).

5.1.5 *24-Hour Simulated Use Test.* During the simulated use test, a total of 64.±3 1.0 gallons (243±3.8 liters) shall be removed. This value is referred to as the daily hot water usage in the following text.

With the water heater turned off, fill the water heater with supply water and apply pressure as described in section 2.5. Turn on the water heater and associated heat pump unit, if present. After the cut-out occurs, the water heater may be operated for up to three cycles of drawing until cut-in, and then operating until cut-out, prior to the start of the test.

At this time, record the mean tank temperature ($\bar{T}_o$), and the electrical and/or fuel measurement readings, as appropriate. Begin the 24-hour simulated use test by withdrawing a volume from the water heater that equals one-sixth of the daily hot water usage. Record the time when this first draw is initiated and assign it as the test elapsed time (τ) of zero (0). Record the average storage tank and ambient temperature every 15 minutes throughout the 24-hour simulated use test unless a recovery or a draw is occurring. At elapsed time intervals of one, two, three, four, and five hours from τ = 0, initiate additional draws, removing an amount of water equivalent to one-sixth of the daily hot water usage with the maximum allowable deviation for any single draw being ±0.5 gallons (1.9 liters). The quantity of water withdrawn during the sixth draw shall be increased or decreased as necessary such that the total volume of water withdrawn equals 64.3 gallons ±1.0 gallon (243.4 liters ±3.8 liters).

All draws during the simulated use test shall be made at flow rates of 3.0 gallons ±0.25 gallons per minute (11.4 liters ±0.95 liters per minute). Measurements of the inlet and outlet temperatures shall be made 15 seconds after the draw is initiated and at every subsequent 5-second interval throughout the duration of each draw. The arithmetic mean of the hot water discharge temperature and the cold water inlet temperature shall be determined for each draw ($\bar{T}_{del,\ i}$ and $\bar{T}_{in,\ i}$). Determine and record the net mass or volume removed (M_i or V_i), as appropriate, after each draw.

At the end of the recovery period following the first draw, record the maximum mean tank temperature observed after cut-out, $\bar{T}_{max,\ 1}$, and the energy consumed by an electric resistance, gas or oil-fired water heater, Q_r. For heat pump water heaters, the total electrical energy consumed during the first recovery by the heat pump (including compressor, fan, controls, pump, etc.) and, if applicable, by the resistive element(s) shall be recorded as Q_r.

At the end of the recovery period that follows the sixth draw, determine and record the total electrical energy and/or fossil fuel consumed since the beginning of the test, Q_{su}. In preparation for determining the energy consumed during standby, record the reading given on the electrical energy (watt-hour) meter, the gas meter, and/or the scale used to determine oil consumption, as appropriate. Record the maximum value of the mean tank temperature after cut-out as $\bar{T}_{su}$. Except as noted below, allow the water heater to remain in the standby mode until 24 hours have elapsed from the start of the test (i.e., since = 0). Prevent the water heater from beginning a recovery cycle during the last hour of the test by turning off the electric power to the electrical heating elements and heat pump, if present, or by turning down the fuel supply to the main burner at an elapsed time of 23 hours. If a recovery is taking place at an elapsed time of 23 hours, wait until the recovery is complete before reducing the electrical and/or fuel supply to the water heater. At 24 hours, record the mean tank temperature, $\bar{T}_{24}$, and the electric and/or fuel instrument readings. Determine the total fossil fuel or electrical energy consumption, as appropriate, for the entire 24-hour simulated use test, Q. Record the time interval between the time at which the maximum mean tank temperature is observed after the sixth draw and the end of the 24-hour test as $_{stby,\ 1}$. Record the time during which water is not being withdrawn from the water heater during the entire 24-hour period as $_{stby,\ 2}$.

5.2 *Instantaneous Gas and Electric Water Heaters*

5.2.1 *Setting the Outlet Discharge Temperature*. Initiate normal operation of the water heater at the full input rating for electric instantaneous water heaters and at the maximum firing rate specified by the manufacturer for gas instantaneous water heaters. Monitor the discharge water temperature and set to a value of 135 °F ±5 °F (57.2 °C ±2.8 °C) in accordance with the manufacturer's instructions. If the water heater is not capable of providing this discharge temperature when the flow rate is 3.0 gallons ±0.25 gallons per minute (11.4 liters ±0.95 liters per minute), then adjust the flow rate as necessary to achieve the specified discharge water temperature. Record the corresponding flow rate as V_{max}.

5.2.2 *Additional Requirements for Variable Input Instantaneous Gas Water Heaters*. If the instantaneous water heater incorporates a controller that permits operation at a reduced input rate, adjust the flow rate as necessary to achieve a discharge water temperature of 135 °F ±5 °F (57.2 °C ±2.8 °C) while maintaining the minimum input rate. Record the corresponding flow rate as V_{min}. If an outlet temperature of 135 °F ±5 °F (57.2 °C ±2.8 °C) cannot be achieved at the minimum flow rate permitted by the instantaneous water heater, record the flow rate as V_{min} and the corresponding outlet temperature as T_{min}.

5.2.3 *Maximum GPM Rating Test for Instantaneous Water Heaters*. Establish normal water heater operation at the full input rate for electric instantaneous water heaters and at the maximum firing rate for gas instantaneous water heaters with the discharge water temperature set in accordance with Section 5.2.1. During the 10-minute test, either collect the withdrawn water for later measurement of the total mass removed, or alternatively, use a water meter to directly measure the water volume removed.

After recording the scale or water meter reading, initiate water flow throughout the water heater, record the inlet and outlet water temperatures beginning 15 seconds after the start of the test and at subsequent 5-second intervals throughout the duration of the test. At the end of 10 minutes, turn off the water. Determine the mass of water collected, M_{10m}, in pounds (kilograms), or the volume of water, V_{10m}, in gallons (liters).

5.2.4 *24-hour Simulated Use Test for Gas Instantaneous Water Heaters*.

5.2.4.1 *Fixed Input Instantaneous Water Heaters*. Establish normal operation with the discharge water temperature and flow rate set to values of 135 °F ±5 °F (57.2 °C ±2.8 °C) and V_{max} per Section 5.2.1, respectively. With no draw occurring, record the reading given by the gas meter and/or the electrical energy meter as appropriate. Begin the 24-hour simulated use test by drawing an amount of water out of the water heater equivalent to one-sixth of the daily hot water usage. Record the time when this first draw is initiated and designate it as an elapsed time, τ, of 0. At elapsed time intervals of one, two, three, four, and five hours from $\tau = 0$, initiate additional draws, removing an amount of water equivalent to one-sixth of the daily hot water usage, with the maximum allowable deviation for any single draw being ±0.5 gallons (1.9 liters). The quantity of water drawn during the sixth draw shall be increased or decreased as necessary such that the total volume of water withdrawn equals 64.3 gallons ±1.0 gallons (243.4 liters ±3.8 liters).

Measurements of the inlet and outlet water temperatures shall be made 15 seconds after the draw is initiated and at every 5-second interval thereafter throughout the duration of the draw. The arithmetic mean of the hot water discharge temperature and the cold water inlet temperature shall be determined for each draw. Record the scale used to measure the mass of the withdrawn water or the water meter reading, as appropriate, after each draw. At the end of the recovery period following the first draw, determine and record the fossil fuel or electrical energy consumed, Q_r. Following the sixth draw and subsequent recovery, allow the water heater to remain in the standby mode until exactly 24 hours have elapsed since the start of the test (i.e., since $\tau = 0$). At 24 hours, record the reading given by the gas meter and/or the electrical energy meter as appropriate. Determine the fossil fuel or electrical energy consumed during the entire 24-hour simulated use test and designate the quantity as Q.

5.2.4.2 *Variable Input Instantaneous Water Heaters*. If the instantaneous water heater incorporates a controller that permits continuous operation at a reduced input rate, the first three draws shall be conducted using the maximum flow rate, V_{max}, while removing an amount of water equivalent to one-sixth of the daily hot water usage, with the maximum allowable deviation for any one of the three draws being ±0.5 gallons (1.9 liters).

The second three draws shall be conducted at V_{min}. If an outlet temperature of 135 °F ±5 °F (57.2 °C ±2.8 °C) could not be achieved at the minimum flow rate permitted by the instantaneous water heater, the last three draws should be lengthened such that the volume removed is:

$$V_{4,5,6} = \frac{64.3\ \text{gal}}{6} \times \left[\frac{77°\text{F}}{(T_{min} - 58°\text{F})}\right]$$

or

$$V_{4,5,6} = \frac{243\ \text{L}}{6} \times \left[\frac{42.8°\text{C}}{(T_{min} - 14.4°\text{C})}\right]$$

where T_{min} is the outlet water temperature at the flow rate V_{min} as determined in Section 5.2.1, and where the maximum allowable variation for any one of the three draws is ±0.5 gallons (1.9 liters). The quantity of water withdrawn during the sixth draw shall be increased or decreased as necessary such that the total volume of water withdrawn equals $(32.15 + 3 \div V_{4,5,6})$ ±1.0 gallons

$((121.7 + 3 \div V_{4,5,6})$ ±3.8 liters).

Measurements of the inlet and outlet water temperatures shall be made 5 seconds after a draw is initiated and at every 5-second interval thereafter throughout the duration of the draw. Determine the arithmetic mean of the hot water discharge temperature and the cold water inlet temperature for each draw. Record the scale used to measure the mass of the withdrawn water or the water meter reading, as appropriate, after each draw. At the end of the recovery period following the first draw, determine and record the fossil fuel or electrical energy consumed, $Q_{r,\ max}$. Likewise, record the reading of the meter used to measure fossil fuel or electrical energy consumption prior to the fourth draw and at the end of the recovery period following the fourth draw, and designate the difference as $Q_{r,min}$. Following the sixth draw and subsequent recovery, allow the water heater to remain in the standby mode until exactly 24 hours have elapsed since the start of the test (i.e., since τ=0). At 24 hours, record the reading given by the gas meter and/or the electrical energy meter, as appropriate. Determine the fossil fuel or electrical energy consumed during the entire 24-hour simulated use test and designate the quantity as Q.

6. Computations

6.1 *Storage Tank and Heat Pump Water Heaters.*

6.1.1 *Storage Tank Capacity.* The storage tank capacity is computed using the following:

$$V_{st} = \frac{(W_f - W_t)}{\rho}$$

Where:

V_{st} = the storage capacity of the water heater, gal (L).
W_f = the weight of the storage tank when completely filled with water, lb (kg).
W_t = the (tare) weight of the storage tank when completely empty, lb (kg).
ρ = the density of water used to fill the tank measured at the temperature of the water, lb/gal (kg/L).

6.1.2. *First-Hour Rating Computation.* For the case in which the final draw is initiated at or prior to an elapsed time of one hour, the first-hour rating shall be computed using,

$$F_{hr} = \sum_{i=1}^{n} V_i^*$$

Where:

n = the number of draws that are completed during the first-hour rating test.
V^*_i = the volume of water removed during the *ith* draw of the first-hour rating test, gal (L)
or, if the mass of water is being measured,

$$V_i^* = \frac{M_i^*}{\rho}$$

Where:

M^*_i = the mass of water removed during the ith draw of the first-hour rating test, lb (kg).
ρ = the water density corresponding to the average outlet temperature measured during the *ith* draw, $(\bar{T}^*_{del,\ I})$, lb/gal (kg/L).

For the case in which a draw is not in progress at the elapsed time of one hour and a final draw is imposed at the elapsed time of one hour, the first-hour rating shall be calculated using

$$F_{hr} = \sum_{i=1}^{n-1} V_i^* + V_n^*\left(\frac{\overline{T}^*_{del,\ n} - T^*_{min,\ n-1}}{\overline{T}^*_{del,\ n-1} - T^*_{min,\ n-1}}\right)$$

where *n* and V^*_i are the same quantities as defined above, and

V^*_n = the volume of water drawn during the nth (final) draw of the first-hour rating test, gal (L)
$\bar{T}^*_{del,n-1}$ = the average water outlet temperature measured during the $(n-1)$th draw of the first-hour rating test, °F (°C).
$\bar{T}^*_{del,n}$ = the average water outlet temperature measured during the *n*th (final) draw of the first-hour rating test, °F (°C).

$\bar{T}^*_{min,n-1}$ = the minimum water outlet temperature measured during the (*n−1*)th draw of the first-hour rating test, °F (°C).

6.1.3 *Recovery Efficiency*. The recovery efficiency for gas, oil, and heat pump storage-type water heaters is computed as:

$$\eta_r = \frac{M_1 C_{p1}\left(\overline{T}_{del,1} - \overline{T}_{in,1}\right)}{Q_r} + \frac{V_{st}\rho_2 C_{p2}\left(\overline{T}_{max,1} - \overline{T}_o\right)}{Q_r}$$

Where:

M_1 = total mass removed during the first draw of the 24-hour simulated use test, lb (kg), or, if the volume of water is being measured,

$M_1 = V_1 \rho_1$

Where:

V_1 = total volume removed during the first draw of the 24-hour simulated use test, gal (L).

ρ_1 = density of the water at the water temperature measured at the point where the flow volume is measured, lb/gal (kg/L).

C_{p1} = specific heat of the withdrawn water, ($\bar{T}_{del,1}$ + $\bar{T}_{in,1}$) 2, Btu/lb °F (kJ/kg °C).

$\bar{T}_{del,1}$ = average water outlet temperature measured during the first draw of the 24-hour simulated use test, °F (°C).

$\bar{T}_{in,1}$ = average water inlet temperature measured during the first draw of the 24-hour simulated use test, °F (°C).

V_{st} = as defined in section 6.1.1.

ρ_2 = density of stored hot water, ($\bar{T}_{max,1}$ + $\bar{T}_o$)/2, lb/gal (kg/L).

C_{p2} = specific heat of stored hot water evaluated at ($\bar{T}_{max,1}$ + $\bar{T}_o$) / 2, Btu/lb °F (kJ/kg$_2$ °C).

$\bar{T}_{max,1}$ = maximum mean tank temperature recorded after cut-out following the first draw of the 24-hour simulated use test, °F (°C).

$\bar{T}_o$ = maximum mean tank temperature recorded prior to the first draw of the 24-hour simulated use test, °F (°C).

Q_r = the total energy used by the water heater between cut-out prior to the first draw and cut-out following the first draw, including auxiliary energy such as pilot lights, pumps, fans, etc., Btu (kJ). (Electrical auxiliary energy shall be converted to thermal energy using the following conversion: 1 kWh = 3,412 Btu.)

The recovery efficiency for electric water heaters with immersed heating elements is assumed to be 98%.

6.1.4 *Hourly Standby Losses*. The hourly standby energy losses are computed as:

$$Q_{hr} = \frac{Q_{stby} - \dfrac{V_{st}\rho C_p\left(\overline{T}_{24} - \overline{T}_{su}\right)}{\eta_r}}{\tau_{stby,1}}$$

Where:

Q_{hr} = the hourly standby energy losses of the water heater, Btu/h (kJ/h).

Q_{stby} = the total energy consumed by the water heater between the time at which the maximum mean tank temperature is observed after the sixth draw and the end of the 24-hour test period, Btu (kJ).

V_{st} = as defined in section 6.1.1.

ρ = density of stored hot water, ($\bar{T}_{24}$ + $\bar{T}_{su}$) / 2, lb/gal (kg/L).

C_p = specific heat of the stored water, ($\bar{T}_{24}$ + $\bar{T}_{su}$) / 2, Btu/lb÷°F (kJ/kg÷°C).

$\bar{T}_{24}$ = the mean tank temperature at the end of the 24-hour simulated use test, °F (°C).

$\bar{T}_{su}$ = the maximum mean tank temperature observed after the sixth draw, °F (°C).

η_r = as defined in section 6.1.3.

$\tau_{stby,\ 1}$ = elapsed time between the time at which the maximum mean tank temperature is observed after the sixth draw and the end of the 24-hour simulated use test, h.

The standby heat loss coefficient for the tank is computed as:

$$UA = \frac{Q_{hr}}{\overline{T}_{t,stby,1} - \overline{T}_{a,stby,1}}$$

Where:

UA = standby heat loss coefficient of the storage tank, Btu/h÷°F (kJ/h÷°C).

Q_{hr} = as defined in this section.

$\bar{T}_{t,\ stby,1}$= overall average storage tank temperature between the time when the maximum mean tank temperature is observed after the sixth draw and the end of the 24-hour simulated use test, °F (°C).

$\bar{T}_{a,\ stby,1}$= overall average ambient temperature between the time when the maximum mean tank temperature is observed after the sixth draw and the end of the 24-hour simulated use test, °F (°C).

6.1.5 *Daily Water Heating Energy Consumption*. The daily water heating energy consumption, Q_d, is computed as:

$$Q_d = Q - \frac{V_{st}\rho C_p\left(\overline{T}_{24} - \overline{T}_o\right)}{\eta_r}$$

Where:

Q = total energy used by the water heater during the 24-hour simulated use test including auxiliary energy such as pilot lights, pumps, fans, etc., Btu (kJ). (Electrical auxiliary energy shall be converted to thermal energy using the following conversion: 1 kWh = 3,412 Btu.)

V_{st} = as defined in section 6.1.1.

ρ= density of the stored hot water, $(\bar{T}_{24} + \bar{T}_o) / 2$, lb/gal (kg/L).

C_p = specific heat of the stored water, $(\bar{T}_{24} + \bar{T}_o) / 2$, Btu/lb÷°F (kJ/kg÷°C).

$\bar{T}_{24}$ = mean tank temperature at the end of the 24-hour simulated use test, °F (°C).

$\bar{T}_o$ = mean tank temperature at the beginning of the 24-hour simulated use test, recorded one minute before the first draw is initiated, °F (°C).

η_r = as defined in section 6.1.3.

6.1.6 *Adjusted Daily Water Heating Energy Consumption.* The adjusted daily water heating energy consumption, Q_{da}, takes into account that the temperature difference between the storage tank and surrounding ambient air may not be the nominal value of 67.5 °F (135 °F–67.5 °F) or 37.5 °C (57.2 °C–19.7 °C) due to the 10 °F (5.6 °C) allowable variation in storage tank temperature, 135 °F ±5 °F (57.2 °C ±2.8 °C), and the 5 °F (2.8 °C) allowable variation in surrounding ambient temperature 65 °F (18.3 °C) to 70 °F (21.1 °C). The adjusted daily water heating energy consumption is computed as:

$Q_{da} = Q_D - [(\bar{T}_{stby,\,2} - \bar{T}_{a,\,stby,2}) - (135\ °F - 67.5\ °F)]\ UA\tau_{stby,\,2}$

or $Q_{da} = Q_D - [(\bar{T}_{stby,\,2} - \bar{T}_{a,\,stby,\,2}) - (57.2\ °C - 19.7\ °C)]\ UA\tau_{stby,\,2}$

Where:

Q_{da} = the adjusted daily water heating energy consumption, Btu (kJ).

Q_d = as defined in section 6.1.5.

$\bar{T}_{stby,\,2}$ = the mean tank temperature during the total standby portion, $\tau_{stby,\,2}$, of the 24-hour test, °F (°C).

$\bar{T}_{a,\,stby,\,2}$ = the average ambient temperature during the total standby portion, $\tau_{stby,\,2}$, of the 24-hour test, °F (°C).

UA = as defined in section 6.1.4.

$\tau_{stby,\,2}$ = the number of hours during the 24-hour simulated test when water is not being withdrawn from the water heater.

A modification is also needed to take into account that the temperature difference between the outlet water temperature and supply water temperature may not be equivalent to the nominal value of 77 °F (135 °F–58 °F) or 42.8 °C (57.2 °C–14.4 °C). The following equations adjust the experimental data to a nominal 77 °F (42.8 °C) temperature rise.

The energy used to heat water, Btu/day (kJ/day), may be computed as:

$$Q_{HW} = \sum_{i=1}^{6} \frac{M_i C_{pi} \left(\overline{T}_{del,\,i} - \overline{T}_{in,\,i}\right)}{\eta_r}$$

Where:

M_i = the mass withdrawn for the *i*th draw (i = 1 to 6), lb (kg).

C_{pi} = the specific heat of the water of the *i*th draw, Btu/lb÷ °F (kJ/kg÷ °C).

$\bar{T}_{del,\,i}$ = the average water outlet temperature measured during the *i*th draw (i=1 to 6), °F (°C).

$\bar{T}_{in,\,i}$ = the average water inlet temperature measured during the *i*th draw (i=1 to 6), °F (°C).

η_r = as defined in section 6.1.3.

The energy required to heat the same quantity of water over a 77 °F (42.8 °C) temperature rise, Btu/day (kJ/day), is:

$$Q_{HW,\,77°F} = \sum_{i=1}^{6} \frac{M_i C_{pi} (135°F - 58°F)}{\eta_r}$$

$$\text{or } Q_{HW,\,42.8°C} = \sum_{i=1}^{6} \frac{M_i C_{pi} (57.2°C - 14.4°C)}{\eta_r}$$

The difference between these two values is:

$Q_{HWD} = Q_{HW,\,77°-F} - Q_{HW}$

or $Q_{HWD} = Q_{HW,42.8°-F} - Q_{HW}$

which must be added to the adjusted daily water heating energy consumption value. Thus, the daily energy consumption value which takes into account that the temperature difference between the storage tank and ambient temperature may not be 67.5 °F (37.5 °C) and that the temperature rise across the storage tank may not be 77 °F (42.8 °C) is:

$Q_{dm} = Q_{da} + Q_{HWD}$

6.1.7 Energy Factor. The energy factor, Ef, is computed as:

$$E_f = \sum_{i=1}^{6} \frac{M_i C_{pi} (135° F - 58° F)}{Q_{dm}}$$

or

$$E_f = \sum_{i=1}^{6} \frac{M_i C_{pi} (57.2° C - 14.4° C)}{Q_{dm}}$$

Where:

Q_{dm} = the modified daily water heating energy consumption as computed in accordance with section 6.1.6, Btu (kJ).

M_i = the mass withdrawn for the ith draw (i = 1 to 6), lb (kg).

C_{pi} = the specific heat of the water of the ith draw, Btu/lb °F (kJ/kg °C).

6.1.8 *Annual Energy Consumption.* The annual energy consumption for storage-type and heat pump water heaters is computed as:

$E_{annual} = 365 \times Q_{dm}$

Where:

Q_{dm} = the modified daily water heating energy consumption as computed in accordance with section 6.1.6, Btu (kJ).

365 = the number of days in a year.

6.2 *Instantaneous Water Heaters.*

6.2.1 *Maximum GPM (L/min) Rating Computation.* Compute the maximum gpm (L/min) rating as:

$$F_{max} = \frac{M_{10m}\left(\overline{T}_{del} - \overline{T}_{in}\right)}{10(\rho)(135°F - 58°F)}$$

$$\text{or } F_{max} = \frac{M_{10m}\left(\overline{T}_{del} - \overline{T}_{in}\right)}{10(\rho)(57.2°C - 14.4°C)}$$

which may be expressed as:

$$F_{max} = \frac{M_{10m}\left(\overline{T}_{del} - \overline{T}_{in}\right)}{10(\rho)(77°F)}$$

$$\text{or } F_{max} = \frac{M_{10m}\left(\overline{T}_{del} - \overline{T}_{in}\right)}{10(\rho)(42.8°C)}$$

Where:

M_{10m} = the mass of water collected during the 10-minute test, lb (kg).

$\bar{T}_{del}$ = the average delivery temperature, °F (°C).

$\bar{T}_{in}$ = the average inlet temperature, °F (°C).

ρ = the density of water at the average delivery temperature, lb/gal (kg/L).

If a water meter is used the maximum gpm (L/min) rating is computed as:

$$F_{max} = \frac{V_{10m}\left(\overline{T}_{del} - \overline{T}_{in}\right)}{10(77°F)}$$

$$\text{or } F_{max} = \frac{V_{10m}\left(\overline{T}_{del} - \overline{T}_{in}\right)}{10(42.8°C)}$$

Where:

V_{10m} = the volume of water measured during the 10-minute test, gal (L).

$\bar{T}_{del}$ = as defined in this section.

$\bar{T}_{in}$ = as defined in this section.

6.2.2 *Recovery Efficiency*

6.2.2.1 *Fixed Input Instantaneous Water Heaters.* The recovery efficiency is computed as:

$$\eta_r = \frac{M_1 C_{p1}\left(\overline{T}_{del,1} - \overline{T}_{in,1}\right)}{Q_r}$$

Where:

M_1 = total mass removed during the first draw of the 24-hour simulated use test, lb (kg), or, if the volume of water is being measured,

$M_1 = V_1 . \rho$

Where:

V_1 = total volume removed during the first draw of the 24-hour simulated use test, gal (L).

ρ= density of the water at the water temperature measured at the point where the flow volume is measured, lb/gal (kg/L).

C_{p1} = specific heat of the withdrawn water, $(\bar{T}_{del,1} + T_{in,1}) / 2$, Btu/lb °F (kJ/kg °C).

$\bar{T}_{del,\ 1}$ = average water outlet temperature measured during the first draw of the 24-hour simulated use test, °F (°C).

$\bar{T}_{in,\ 1}$ = average water inlet temperature measured during the first draw of the 24-hour simulated use test, °F (°C).

Q_r = the total energy used by the water heater between cut-out prior to the first draw and cut-out following the first draw, including auxiliary energy such as pilot lights, pumps, fans, etc., Btu (kJ). (Electrical auxiliary energy shall be converted to thermal energy using the following conversion: 1 kWh = 3,412 Btu.)

6.2.2.2 *Variable Input Instantaneous Water Heaters.* For instantaneous water heaters that have a variable firing rate, two recovery efficiency values are computed, one at the maximum input rate and one at the minimum input rate. The recovery efficiency used in subsequent computations is taken as the average of these two values. The maximum recovery efficiency is computed as:

$$\eta_{r,\,max} = \frac{M_1 C_{p1}\left(\overline{T}_{del,1} - \overline{T}_{in,1}\right)}{Q_{r,\,max}}$$

Where:

M_1 = as defined in section 6.2.2.1.

C_{p1} = as defined in section 6.2.2.1.

$\bar{T}_{del,\ 1}$ = as defined in section 6.2.2.1.

$\bar{T}_{in,\ 1}$ = as defined in section 6.2.2.1.

$Q_{r,\ max}$ = the total energy used by the water heater between burner cut-out prior to the first draw and burner cut-out following the first draw, including auxiliary energy such as pilot lights, Btu (kJ).

The minimum recovery efficiency is computed as:

$$\eta_{r,\,min} = \frac{M_4 C_{p4}\left(\overline{T}_{del,4} - \overline{T}_{in,4}\right)}{Q_{r,\,min}}$$

Where:

M_4 = the mass withdrawn during the fourth draw, lb (kg), or, if the volume of water is being measured,

$M_4 = V_4\ \rho$

Where:

V_4 = total volume removed during the first draw of the 24-hour simulated use test, gal (L).

ρ = as defined in 6.2.2.1

C_{p4} = the specific heat of water, Btu/lb °F (kJ/kg °C).

$\bar{T}_{del,\ 4}$ = the average delivery temperature for the fourth draw, °F (°C).
$\bar{T}_{in,\ 4}$ = the average inlet temperature for the fourth draw, °F (°C).
$Q_{r,\ min}$ = the total energy consumed between the beginning of the fourth draw and burner cut-out following the fourth draw, including auxiliary energy such as pilot lights, Btu (kJ).

The recovery efficiency is computed as:

$$\eta_r = \frac{\eta_{r,\,max} + \eta_{r,\,min}}{2}$$

Where:

$\eta_{r,max}$ = as calculated above.
$\eta_{r,min}$ = as calculated above.

6.2.3 *Daily Water Heating Energy Consumption*. The daily water heating energy consumption, Q_d, is computed as:

$Q_d = Q$

Where:

Q = the energy used by the instantaneous water heater during the 24-hr simulated use test.

A modification is needed to take into account that the temperature difference between the outlet water temperature and supply water temperature may not be equivalent to the nominal value of 77 °F (135 °F − 58 °F) or 42.8 °C (57.2 °C − 14.4 °C). The following equations adjust the experimental data to a nominal 77 °F (42.8 °C) temperature rise.

The energy used to heat water may be computed as:

$$Q_{HW} = \sum_{i=1}^{6} \frac{M_i C_{pi} \left(\overline{T}_{del,\,i} - \overline{T}_{in,\,i} \right)}{\eta_r}$$

Where:

M_i = the mass withdrawn during the ith draw, lb (kg).
C_{pi} = the specific heat of water of the ith draw, Btu/lb °F (kJ/kg (°C).
$\bar{T}_{del,i}$ = the average delivery temperature of the ith draw, °F (°C).
$\bar{T}_{in,i}$ = the average inlet temperature of the ith draw, °F (°C).
η_r = as calculated in section 6.2.2.2.

The energy required to heat the same quantity of water over a 77 °F (42.8 °C) temperature rise is:

$$Q_{HW,\,77°F} = \sum_{i=1}^{6} \frac{M_i C_{pi} (135°F - 58°F)}{\eta_r}$$

$$\text{or } Q_{HW,\,42.8°C} = \sum_{i=1}^{6} \frac{M_i C_{pi} (57.2℃ - 14.4℃)}{\eta_r}$$

Where:

M_i = the mass withdrawn during the *i*th draw, lb (kg).
C_{pi} = the specific heat of water of the ith draw, Btu/lb °F (kJ/kg (°C).
η_r = as calculated above.

The difference between these two values is:

$Q_{HWD} = Q_{HW,\ 77\ °F} - Q_{HW}$
or $Q_{HWD} = Q_{HW,\ 42.8\ °C} - Q_{HW}$

which much be added to the daily water heating energy consumption value. Thus, the daily energy consumption value which takes into account that the temperature rise across the storage tank may not be 77 °F (42.8 °C) is:

$Q_{dm} = Q_d + Q_{HWD}$

6.2.4 *Energy Factor*. The energy factor, E_f, is computed as:

$$E_f = \sum_{i=1}^{6} \frac{M_i C_{pi} (135°F - 58°F)}{Q_{dm}}$$

$$\text{or } E_f = \sum_{i=1}^{6} \frac{M_i C_{pi} (57.2°C - 14.4°C)}{Q_{dm}}$$

Where:

Q_{dm} = the daily water heating energy consumption as computed in accordance with section 6.2.3, Btu (kJ).
M_i = the mass associated with the *i*th draw, lb (kg).
C_{pi} = the specific heat of water computed at a temperature of (58 °F + 135 °F) / 2, Btu/lb °F [(14.4 °C + 57.2 °C) / 2, kJ/kg °C].

6.2.5 *Annual Energy Consumption*. The annual energy consumption for instantaneous type water heaters is computed as:

$E_{annual} = 365 \times Q_{dm}$

Where:

Q_{dm} = the modified daily energy consumption, Btu/day (kJ/day).
365 = the number of days in a year.

7. Ratings for Untested Models

In order to relieve the test burden on manufacturers who offer water heaters which differ only in fuel type or power input, ratings for untested models may be established in accordance with the following procedures. In lieu of the following procedures a manufacturer may elect to test the unit for which a rating is sought.

7.1 *Gas Water Heaters*. Ratings obtained for gas water heaters using natural gas can be used for an identical water heater which utilizes propane gas if the input ratings are within ±10%.

7.2 *Electric Water Heaters*

7.2.1 *First-Hour Rating*. If an electric storage-type water heater is available with more than one input rating, the manufacturer shall designate the standard input rating, and the water heater need only be tested with heating elements at the designated standard input ratings. The first-hour ratings for units having power input rating less than the designated standard input rating shall be assigned a first-hour rating equivalent to the first draw of the first-hour rating for the electric water heater with the standard input rating. For units having power inputs greater than the designated standard input rating, the first-hour rating shall be equivalent to that measured for the water heater with the standard input rating.

7.2.2 *Energy Factor*. The energy factor for identical electric storage-type water heaters, with the exception of heating element wattage, may use the energy factor obtained during testing of the water heater with the designated standard input rating.

[63 FR 26008, May 11, 1998; 63 FR 38738, July 20, 1998, as amended at 66 FR 4497, Jan. 17, 2001]

APPENDIX F TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF ROOM AIR CONDITIONERS

NOTE: Manufacturers are not required to use the test procedures and calculations that refer to standby mode and off mode energy consumption, (specifically, sections 2.2, 3.2, 4.2, and 5.3 of this appendix F) until the compliance date of any amended energy conservation standards for room air conditioners at 10 CFR 430.32(b).

1. *Definitions*.

1.1 ''Active mode'' means a mode in which the room air conditioner is connected to a mains power source, has been activated and is performing the main function of cooling or heating the conditioned space, or circulating air through activation of its fan or blower, with or without energizing active air-cleaning components or devices such as ultraviolet (UV) radiation, electrostatic filters, ozone generators, or other air-cleaning devices.

1.2 ''ANSI/AHAM RAC–1'' means the test standard published jointly by the American National Standards Institute and the Association of Home Appliance Manufacturers, titled ''Room Air Conditioners,'' Standard RAC–1–2008 (incorporated by reference; see § 430.3).

1.3 ''ANSI/ASHRAE 16'' means the test standard published jointly by the American National Standards Institute and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers titled ''Method of Testing for Rating Room Air Conditioners and Packaged Terminal Air Conditioners,'' Standard 16–1983 (RA 2009) (incorporated by reference; see § 430.3).

1.4 ''IEC 62301'' means the test standard published by the International Electrotechnical Commission, (''IEC''), titled ''Household electrical appliances—Measurement of standby power,'' Publication 62301 (first edition June 2005), (incorporated by reference; see § 430.3).

1.5 ''Inactive mode'' means a standby mode that facilitates the activation of active mode by remote switch (including remote control) or internal sensor or which provides continuous status display.

1.6 ''Off mode'' means a mode in which a room air conditioner is connected to a mains power source and is not providing any active or standby mode function and where the mode may persist for an indefinite time. An indicator that only shows the user that the product is in the off position is included within the clasification of an off mode.

1.7 ''Standby mode'' means any product modes where the where the energy using product is connected to a mains power source and offers one or more of the following user oriented or protective functions which may persist for an indefinite time:

(a) To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, or timer.

(b) Continuous functions, including information or status displays (including clocks) or sensor-based functions. A timer is a continuous clock function (which may or may not be associated with a display) that provides regular scheduled tasks (*e.g.*, switching) and that operates on a continuous basis.

2. *Test methods*.

2.1 *Cooling*. The test method for testing room air conditioners in cooling mode shall consist of application of the methods and conditions in ANSI/AHAM RAC–1 sections 4, 5, 6.1, and 6.5 (incorporated by reference; see § 430.3), and in ANSI/ASHRAE 16 (incorporated by reference; see § 430.3).

2.2 *Standby and off modes*. The method for testing room air conditioners in standby and off modes shall consist of application of the methods and conditions in IEC 62301 (incorporated by reference; see § 430.3), as modified by the requirements of this standard. The testing may be conducted in test facilities used for testing cooling performance. If testing is not conducted in such a facility, the test facility shall comply with IEC 62301 section 4.2.

3. *Test conditions*.

3.1 *Cooling mode*. Establish the test conditions described in sections 4 and 5 of ANSI/AHAM RAC–1 (incorporated by reference; see § 430.3) and in accordance with ANSI/ASHRAE 16 (incorporated by reference; see § 430.3).

3.2 *Standby and off modes*.

3.2.1 *Test room conditions*. Maintain the indoor test conditions as required by section 4.2 of IEC 62301 (incorporated by reference;

see §430.3). If the standby and off mode testing is conducted in a facility that is also used for testing cooling performance, maintain the outdoor test conditions either as required by section 4.2 of IEC 62301 or as described in section 3.1. If the unit is equipped with an outdoor air ventilation damper, close this damper during testing.

3.2.2 *Power supply*. Maintain power supply conditions specified in section 4.3 of IEC 62301 (incorporated by reference; see §430.3). Use room air conditioner nameplate voltage and frequency as the basis for power supply conditions. Maintain power supply voltage waveform according to the requirements of section 4.4 of IEC 62301.

3.2.3 *Watt meter*. The watt meter used to measure standby mode and off mode power consumption of the room air conditioner shall have the resolution specified in section 4, paragraph 4.5 of IEC 62301 (incorporated by reference; see §430.3). The watt meter shall also be able to record a ''true'' average power specified in section 5, paragraph 5.3.2(a) of IEC 62301.

4. *Measurements*.

4.1 *Cooling mode*. Measure the quantities delineated in section 5 of ANSI/AHAM RAC–1 (incorporated by reference; see §430.3).

4.2 *Standby and off modes*. Establish the testing conditions set forth in section 3.2. Prior to the initiation of the test measurements, the room air conditioner shall also be installed in accordance with section 5, paragraph 5.2 of IEC 62301 (incorporated by reference; see §430.3). For room air conditioners that drop from a higher power state to a lower power state as discussed in section 5, paragraph 5.1, note 1 of IEC 62301, allow sufficient time for the room air conditioner to reach the lower power state before proceeding with the test measurement. Follow the test procedure specified in section 5, paragraph 5.3 of IEC 62301 for testing in each possible mode as described in 4.2.1 and 4.2.2, except allow the product to stabilize for 5 to 10 minutes and use an energy use measurement period of 5 minutes. For units in which power varies over a cycle, as described in section 5, paragraph 5.3.2 of IEC 62301, use the average power approach in paragraph 5.3.2(a).

4.2.1 If a room air conditioner has an inactive mode, as defined in 1.5, measure and record the average inactive mode power of the room air conditioner, P_{IA}, in watts.

4.2.2 If a room air conditioner has an off mode, as defined in 1.6, measure and record the average off mode power of the room air conditioner, P_{OFF}, in watts.

5. *Calculations*.

5.1 Calculate the cooling capacity (expressed in Btu/hr) as required in section 6.1 of ANSI/AHAM RAC–1 (incorporated by reference; see §430.3) and in accordance with ANSI/ASHRAE 16 (incorporated by reference; see §430.3).

5.2 Determine the electrical power input (expressed in watts) as required by section 6.5 of ANSI/AHAM RAC–1 (incorporated by reference; see §430.3) and in accordance with ANSI/ASHRAE 16 (incorporated by reference; see §430.3).

5.3 *Standby mode and off mode annual energy consumption*. Calculate the standby mode and off mode annual energy consumption for room air conditioners, E_{TSO}, expressed in kilowatt-hours per year, according to the following:

$$E_{TSO} = [(P_{IA} \times S_{IA}) + (P_{OFF} \times S_{OFF})] \times K$$

Where:

P_{IA}= room air conditioner inactive mode power, in watts, as measured in section 4.2.1

P_{OFF} = room air conditioner off mode power, in watts, as measured in section 4.2.2.

If the room air conditioner has both inactive mode and off mode, S_{IA} and S_{OFF} both equal 5,115 ÷ 2 = 2,557.5, where 5,115 is the total inactive and off mode annual hours;

If the room air conditioner has an inactive mode but no off mode, the inactive mode annual hours, S_{IA}, is equal to 5,115 and the off mode annual hours, S_{OFF}, is equal to 0;

If the room air conditioner has an off mode but no inactive mode, S_{IA} is equal to 0 and S_{OFF} is equal to S_{TOT};

K = 0.001 kWh/Wh conversion factor for watt-hours to kilowatt-hours.

[76 FR 1035, Jan. 6, 2011]

APPENDIX G TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF UNVENTED HOME HEATING EQUIPMENT

1. Testing conditions.

1.1 *Installation*.

1.1.1 *Electric heater*. Install heater according to manufacturer's instructions. Heaters shall be connected to an electrical supply circuit of nameplate voltage with a wattmeter installed in the circuit. The wattmeter shall have a maximum error not greater than one percent.

1.1.2 *Unvented gas heater*. Install heater according to manufacturer's instructions. Heaters shall be connected to a gas supply line with a gas displacement meter installed between the supply line and the heater according to manufacturer's specifications. The gas displacement meter shall have a maximum error not greater than one percent. Gas heaters with electrical auxiliaries shall be connected to an electrical supply circuit of nameplate voltage with a wattmeter installed in the circuit. The wattmeter shall have a maximum error not greater than one percent.

1.1.3 *Unvented oil heater*. Install heater according to manufacturer's instructions. Oil heaters with electric auxiliaries shall be connected to an electrical supply circuit of nameplate voltage with a wattmeter installed in the circuit. The wattmeter shall have a maximum error not greater than one percent.

1.2 *Temperature regulating controls*. All temperature regulating controls shall be shorted out of the circuit or adjusted so that they will not operate during the test period.

1.3 *Fan controls*. All fan controls shall be set at the highest fan speed setting.

1.4 *Energy supply*.

1.4.1 *Electrical supply*. Supply power to the heater within one percent of the nameplate voltage.

1.4.2 *Natural gas supply*. For an unvented gas heater utilizing natural gas, maintain the gas supply to the heater with a normal inlet test pressure immediately ahead of all controls at 7 to 10 inches of water column. The regulator outlet pressure at normal supply test pressure shall be approximately that recommended by the manufacturer. The natural gas supplied should have a higher heating value within ±5 percent of 1,025 Btu's per standard cubic foot. Determine the higher heating value, in Btu's per standard cubic foot, for the natural gas to be used in the test, with an error no greater than one percent. Alternatively, the test can be conducted using ''bottled'' natural gas of a higher heating value within ±5 percent of 1,025 Btu's per standard cubic foot as long as the actual higher heating value of the bottled natural gas has been determined with an error no greater than one percent as certified by the supplier.

1.4.3 *Propane gas supply*. For an unvented gas heater utilizing propane, maintain the gas supply to the heater with a normal inlet test pressure immediately ahead of all controls at 11 to 13 inches of water column. The regulator outlet pressure at normal supply test pressure shall be that recommended by the manufacturer. The propane supplied should have a higher heating value of within±5 percent of 2,500 Btu's per standard cubic foot. Determine the higher heating value in Btu's per standard foot, for the propane to be used in the test, with an error no greater than one percent. Alternatively, the test can be conducted using ''bottled'' propane of a higher heating value within ±5 percent of 2,500 Btu's per standard cubic foot as long as the actual higher heating value of the bottled propane has been determined with an error no greater than one percent as certified by the supplier.

1.4.4 *Oil supply*. For an unvented oil heater utilizing kerosene, determine the higher heating value in Btu's per gallon with an error no greater than one percent. Alternatively, the test can be conducted using a tested fuel of a higher heating value within ±5 percent of 137,400 Btu's per gallon as long as the actual higher heating value of the tested fuel has been determined with an error no greater than one percent as certified by the supplier.

1.5 *Energy flow instrumentation*. Install one or more energy flow instruments which measure, as appropriate and with an error no greater than one percent, the quantity of electrical energy, natural gas, propane gas, or oil supplied to the heater.

2. Testing and measurements.

2.1 *Electric power measurement*. Establish the test conditions set forth in section 1 of this appendix. Allow an electric heater to warm up for at least five minutes before recording the maximum electric power measurement from the wattmeter. Record the maximum electric power (P_E) expressed in kilowatts.

Allow the auxiliary electrical system of a forced air unvented gas, propane, or oil heater to operate for at least five minutes before recording the maximum auxiliary electric power measurement from the wattmeter. Record the maximum auxiliary electric power (P_A) expressed in kilowatts.

2.2 *Natural gas, propane, and oil measurement*. Establish the test conditions as set forth in section 1 of this appendix. A natural gas, propane, or oil heater shall be operated for one hour. Using either the nameplate rating or the energy flow instrumentation set forth in section 1.5 of this appendix and the fuel supply rating set forth in sections 1.4.2, 1.4.3, or 1.4.4 of this appendix, as appropriate, determine the maximum fuel input (P_F) of the heater under test in Btu's per hour. The energy flow instrumentation shall measure the maximum fuel input with an error no greater than one percent.

3. Calculations.

3.1 *Annual energy consumption for primary electric heaters*. For primary electric heaters, calculate the annual energy consumption (E_E) expressed in kilowatt-hours per year and defined as:

E_E=2080(0.77)DHR

where:

2080=national average annual heating load hours

0.77=adjustment factor

DHR=design heating requirement and is equal to P_E/1.2 in kilowatts.

P_E=as defined in 2.1 of this appendix

1.2=typical oversizing factor for primary electric heaters

3.2 *Annual energy consumption for primary electric heaters by geographic region of the United States*. For primary electric heaters, calculate the annual energy consumption by geographic region of the United States (E_R)

expressed in kilowatt-hours per year and defined as:

E_R=HLH(0.77) (DHR)

where:

HLH=heating load hours for a specific region determined from Figure 1 of this appendix in hours

0.77=as defined in 3.1 of this appendix

DHR=as defined in 3.1 of this appendix

3.3 *Rated output for electric heaters.* Calculate the rated output (Q_{out}) for electric heaters, expressed in Btu's per hour, and defined as:

Q_{out}=P_E (3,412 Btu/kWh)

where:

P_E=as defined in 2.1 of this appendix

3.4 *Rated output for unvented heaters using either natural gas, propane, or oil.* For unvented heaters using either natural gas, propane, or oil equipped without auxiliary electrical systems, the rated output (Q_{out}), expressed in Btu's per hour, is equal to P_F, as determined in section 2.2 of this appendix.

For unvented heaters using either natural gas, propane, or oil equipped with auxiliary electrical systems, calculate the rated output (Q_{out}), expressed in Btu's per hour, and defined as:

Q_{out}=P_F+P_A (3,412 Btu/kWh)

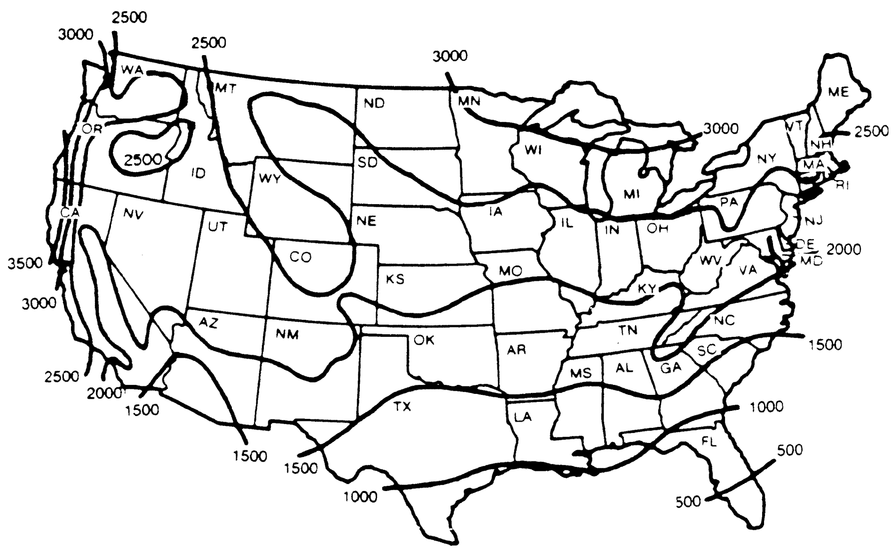
where:

P_F=as defined in 2.2 of this appendix in Btu/hr

P_A=as defined in 2.1 of this appendix in Btu/hr

FIGURE I

Heating Load Hours (HLH) for the United States and Territories



This map is reasonably accurate for most parts of the United States but is necessarily highly generalized and consequently not too accurate in mountainous regions, particularly in the Rockies

Alaska	— 3500 HLH
Hawaii and Territories	— O HLH

(Energy Policy and Conservation Act, Pub. L. 94–163, as amended by Pub. L. 94–385; Federal Energy Administration Act of 1974, Pub. L. 93–275, as amended by Pub. L. 94–385; Department of Energy Organization Act, Pub. L. 95–91; E.O. 11790, 39 FR 23185)

[43 FR 20132, May 10, 1978. Redesignated and amended at 44 FR 37938, June 29, 1979; 49 FR 12157, Mar. 28, 1984]

APPENDIX H TO SUBPART B OF PART 430 [RESERVED]

APPENDIX I TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF CONVENTIONAL RANGES, CONVENTIONAL COOKING TOPS, CONVENTIONAL OVENS, AND MICROWAVE OVENS

NOTE: The procedures and calculations in this appendix need not be performed to determine compliance with energy conservation standards for conventional ranges, conventional cooking tops, conventional ovens, and microwave ovens at this time. However, any representation related to standby mode and off mode energy consumption of these products made after September 6, 2011 must be based upon results generated under this test procedure, consistent with the requirements of 42 U.S.C. 6293(c)(2). After July 1, 2010, however, when DOE adopts an energy conservation standard that incorporates standby mode and off mode energy consumption, and upon the compliance date for such standards, compliance with the applicable provisions of this test procedure will also be required. Future revisions may add relevant provisions for measuring active mode in microwave ovens.

1. Definitions

1.1 *Active mode* means a mode in which a conventional cooking top, conventional oven, conventional range, or microwave oven is connected to a mains power source, has been activated, and is performing the main function of producing heat by means of a gas flame, electric resistance heating, or microwave energy. Delay start mode is a one off user-initiated short duration function that is associated with an active mode.

1.2 *Built-in* means the product is supported by surrounding cabinetry, walls, or other similar structures.

1.3 *Drop-in* means the product is supported by horizontal surface cabinetry.

1.4 *Forced convection* means a mode of conventional oven operation in which a fan is used to circulate the heated air within the oven compartment during cooking.

1.5 *Freestanding* means the product is not supported by surrounding cabinetry, walls, or other similar structures.

1.6 *IEC 62301* refers to the test standard published by the International Electrotechnical Commission, titled ''Household electrical appliances—Measurement of standby power,'' Publication 62301 (first edition June 2005). (incorporated by reference, see §430.3)

1.7 *Normal nonoperating temperature* means the temperature of all areas of an appliance to be tested are within 5 °F (2.8 °C) of the temperature that the identical areas of the same basic model of the appliance would attain if it remained in the test room for 24 hours while not operating with all oven doors closed and with any gas pilot lights on and adjusted in accordance with manufacturer's instructions.

1.8 *Off mode* means a mode in which a conventional cooking top, conventional oven, conventional range, or microwave oven is connected to a mains power source and is not providing any active mode or standby mode function and where the mode may persist for an indefinite time. An indicator that only shows the user that the product is in the off position is included within the classification of an off mode.

1.9 *Primary energy consumption* means either the electrical energy consumption of a conventional electric oven or the gas energy consumption of a conventional gas oven.

1.10 *Secondary energy consumption* means any electrical energy consumption, other than clock energy consumption, of a conventional gas oven.

1.11 *Standard cubic foot (L) of gas* means that quantity of gas that occupies 1 cubic foot (L) when saturated with water vapor at a temperature of 60 °F (15.6 °C) and a pressure of 30 inches of mercury (101.6 kPa) (density of mercury equals 13.595 grams per cubic centimeter).

1.12 *Standby mode* means any mode in which a conventional cooking top, conventional oven, conventional range, or microwave oven is connected to a mains power source and offers one or more of the following user-oriented or protective functions which may persist for an indefinite time: (a) To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, or timer; (b) continuous functions, including information or status displays (including clocks) or sensor-based functions. A timer is a continuous clock function (which may or may not be associated with a display) that allows for regularly scheduled tasks and that operates on a continuous basis.

1.13 *Thermocouple* means a device consisting of two dissimilar metals which are joined together and, with their associated wires, are used to measure temperature by means of electromotive force.

1.14 *Symbol usage.* The following identity relationships are provided to help clarify the symbology used throughout this procedure.

A—Number of Hours in a Year
B—Number of Hours Pilot Light Contributes to Cooking
C—Specific Heat
E—Energy Consumed
Eff—Cooking Efficiency
H—Heating Value of Gas
K—Conversion for Watt-hours to Kilowatt-hours
K_e—3.412 Btu/Wh, Conversion for Watt-hours to Btu's
M—Mass
n—Number of Units
O—Annual Useful Cooking Energy Output
P—Power
Q—Gas Flow Rate
R—Energy Factor, Ratio of Useful Cooking Energy Output to Total Energy Input
S—Number of Self-Cleaning Operations per Year
T—Temperature
t—Time
V—Volume of Gas Consumed
W—Weight of Test Block

2. Test Conditions

2.1 *Installation.* A free standing kitchen range shall be installed with the back directly against, or as near as possible to, a vertical wall which extends at least 1 foot above and on either side of the appliance. There shall be no side walls. A drop-in, built-in or wall-mounted appliance shall be installed in an enclosure in accordance with the manufacturer's instructions. These appliances are to be completely assembled with all handles, knobs, guards and the like mounted in place. Any electric resistance heaters, gas burners, baking racks, and baffles shall be in place in accordance with the manufacturer's instructions; however, broiler pans are to be removed from the oven's baking compartment. Disconnect any electrical clock which uses energy continuously, except for those that are an integral part of the timing or temperature controlling circuit of the oven, cooktop, or microwave oven. Do not disconnect or modify the circuit to any other electrical devices or features.

2.1.1 *Conventional electric ranges, ovens, and cooking tops.* These products shall be connected to an electrical supply circuit with voltage as specified in Section 2.2.1 with a watt-hour meter installed in the circuit. The watt-hour meter shall be as described in Section 2.9.1.1.

2.1.2 *Conventional gas ranges, ovens, and cooking tops.* These products shall be connected to a gas supply line with a gas meter installed between the supply line and the appliance being tested, according to manufacturer's specifications. The gas meter shall be as described in Section 2.9.2. Conventional gas ranges, ovens and cooking tops with electrical ignition devices or other electrical components shall be connected to an electrical supply circuit of nameplate voltage with a watt-hour meter installed in the circuit. The watt-hour meter shall be as described in Section 2.9.1.1.

2.1.3 *Microwave ovens.* Install the microwave oven in accordance with the manufacturer's instructions and connect to an electrical supply circuit with voltage as specified in section 2.2.1. The microwave oven shall also be installed in accordance with Section 5, Paragraph 5.2 of IEC 62301 (incorporated by reference; see §430.3). A watt meter shall be installed in the circuit and shall be as described in section 2.9.1.3.

2.2 *Energy supply.*

2.2.1 *Electrical supply.*

2.2.1.1 *Voltage.* Maintain the electrical supply to the conventional range, conventional cooking top, and conventional oven being tested at 240/120 volts except that basic models rated only at 208/120 volts shall be tested at that rating. Maintain the voltage within 2 percent of the above specified voltages. For microwave oven testing, maintain the electrical supply to the microwave oven at 120/240 volts and 60 hertz. For conventional range, conventional cooking top, and conventional oven standby mode and off mode testing, maintain the electrical supply frequency at 60 hertz ± 1 percent. Maintain the electrical supply for microwave oven testing within 1 percent of the specified voltage and frequency.

2.2.1.2 *Supply voltage waveform.* For the standby mode and off mode testing, maintain the electrical supply voltage waveform as indicated in Section 4, Paragraph 4.4 of IEC 62301 (incorporated by reference; see §430.3).

2.2.2 *Gas supply.*

2.2.2.1 *Gas burner adjustments.* Conventional gas ranges, ovens, and cooking tops shall be tested with all of the gas burners adjusted in accordance with the installation or operation instructions provided by the manufacturer. In every case, the burner must be adjusted with sufficient air flow to prevent a yellow flame or a flame with yellow tips.

2.2.2.2 *Natural gas.* For testing convertible cooking appliances or appliances which are designed to operate using only natural gas, maintain the natural gas pressure immediately ahead of all controls of the unit under test at 7 to 10 inches of water column (1743.6 to 2490.8 Pa). The regulator outlet pressure shall equal the manufacturer's recommendation. The natural gas supplied should have a heating value of approximately 1,025 Btu's per standard cubic foot (38.2 kJ/L). The actual gross heating value, H_n, in Btu's per standard cubic foot (kJ/L), for the natural gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using equipment that meets the requirements described in Section 2.9.4 or by the use of bottled natural gas whose gross heating value is certified to be at least as accurate a value that meets the requirements in Section 2.9.4.

2.2.2.3 *Propane.* For testing convertible cooking appliances with propane or for testing appliances which are designed to operate using only LP-gas, maintain the propane pressure immediately ahead of all controls of the unit under test at 11 to 13 inches of water column (2740 to 3238 Pa). The regulator outlet pressure shall equal the manufacturer's recommendation. The propane supplied should have a heating value of approximately 2,500 Btu's per standard cubic foot (93.2 kJ/L). The actual gross heating value, H_p, in Btu's per standard cubic foot (kJ/L), for the propane to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using equipment that meets the requirements described in Section 2.9.4 or by the use of bottled propane whose gross heating value is certified to be at least as accurate a value that meets the requirements described in Section 2.9.4.

2.2.2.4 *Test gas.* A basic model of a convertible cooking appliance shall be tested with natural gas, but may also be tested with propane. Any basic model of a conventional range, conventional cooking top, or conventional oven which is designed to operate using only natural gas as the energy source must be tested with natural gas. Any basic model of a conventional range, conventional cooking top, or conventional oven which is designed to operate using only LP gas as the gas energy source must be tested with propane gas.

2.3 *Air circulation.* Maintain air circulation in the room sufficient to secure a reasonably uniform temperature distribution, but do not cause a direct draft on the unit under test.

2.4 *Setting the conventional oven thermostat.*

2.4.1 *Conventional electric oven.* Install a thermocouple approximately in the center of the usable baking space. Provide a temperature indicator system for measuring the oven's temperature with an accuracy as indicated in Section 2.9.3.2. If the oven thermostat does not cycle on and off, adjust or determine the conventional electric oven thermostat setting to provide an average internal temperature which is 325°±5 °F (180.6° ±2.8 °C) higher than the room ambient air temperature. If the oven thermostat operates by cycling on and off, adjust or determine the conventional electric oven thermostat setting to provide an average internal temperature which is 325° ±5 °F (180.6°±2.8 °C) higher than the room ambient air temperature. This shall be done by measuring the maximum and minimum temperatures in any three consecutive cut-off/cut-on actions of the electric resistance heaters, excluding the initial cut-off/cut-on action, by the thermostat after the temperature rise of 325°±5 °F (180.6° ±2.8 °C) has been attained by the conventional electric oven. Remove the thermocouple after the thermostat has been set.

2.4.2 *Conventional gas oven.* Install five parallel-connected weighted thermocouples, one located at the center of the conventional gas oven's usable baking space and the other four equally spaced between the center and the corners of the conventional gas oven on the diagonals of a horizontal plane through the center of the conventional gas oven. Each weighted thermocouple shall be constructed of a copper disc that is 1-inch (25.4 mm) in diameter and ⅛-inch (3.2 mm) thick. The two thermocouple wires shall be located in two holes in the disc spaced ½-inch (12.7 mm) apart, with each hole being located ¼-inch (6.4 mm) from the center of the disc. Both thermocouple wires shall be silver-soldered to the copper disc. Provide a temperature indicator system for measuring the oven's temperature with an accuracy as indicated in Section 2.9.3.2. If the oven thermostat does not cycle on or off, adjust or determine the conventional gas oven thermostat setting to provide an average internal temperature which is 325 °±5 °F (180.6 °±2.8 °C) higher than the room ambient air temperature. If the oven thermostat operates by cycling on and off, adjust or determine the conventional gas oven thermostat setting to provide an average internal temperature which is 325°±5 °F (180.6±2.8 °C) higher than the room ambient air temperature. This shall be done by measuring the maximum and minimum temperatures in any three consecutive cut-off/cut-on actions of the gas burners, excluding the initial cut-off/cut-on action, by the thermostat after the temperature rise of 325°±5 °F (180.6 °±2.8 °C) has been attained by the conventional gas oven. Remove the thermocouples after the thermostat has been set.

2.5 *Ambient room air temperature.*

2.5.1 *Active mode ambient room air temperature.* During the active mode test, maintain an ambient room air temperature, $T_{R,}$ of 77° ± 9 °F (25 ° ± 5 °C) for conventional ovens and cooking tops, as measured at least 5 feet (1.5 m) and not more than 8 feet (2.4 m) from the nearest surface of the unit under test and approximately 3 feet (0.9 m) above the floor. The temperature shall be measured with a thermometer or temperature indicating system with an accuracy as specified in section 2.9.3.1.

2.5.2 *Standby mode and off mode ambient temperature.* For standby mode and off mode testing, maintain room ambient air temperature conditions as specified in Section 4, Paragraph 4.2 of IEC 62301 (incorporated by reference; see § 430.3).

2.6 *Normal nonoperating temperature.* All areas of the appliance to be tested shall attain the normal nonoperating temperature, as defined in section 1.7, before any testing begins. The equipment for measuring the applicable normal nonoperating temperature shall be as described in sections 2.9.3.1, 2.9.3.2, 2.9.3.3, and 2.9.3.4, as applicable.

2.7 *Test blocks for conventional oven and cooking top.* The test blocks shall be made of aluminum alloy No. 6061, with a specific heat of 0.23 Btu/lb- °F (0.96 kJ/[kg ÷ °C]) and with any temper that will give a czoefficient of thermal conductivity of 1073.3 to 1189.1 Btu-in/h-ft^2- °F (154.8 to 171.5 W/[m ÷ °C]). Each block shall have a hole at its top. The hole shall be 0.08 inch (2.03 mm) in diameter and 0.80 inch (20.3 mm) deep. The manufacturer conducting the test may provide other means which will ensure that the thermocouple junction is installed at this same position and depth.

The bottom of each block shall be flat to within 0.002 inch (0.051 mm) TIR (total indicator reading). Determine the actual weight of each test block with a scale with an accuracy as indicated in Section 2.9.5.

2.7.1 *Conventional oven test block.* The test block for the conventional oven, W_1, shall be 6.25±0.05 inches (158.8±1.3 mm) in diameter, approximately 2.8 inches (71 mm) high and shall weigh 8.5±0.1 lbs (3.86±0.05 kg). The block shall be finished with an anodic black coating which has a minimum thickness of 0.001 inch (0.025 mm) or with a finish having the equivalent absorptivity.

2.7.2 *Small test block for conventional cooking top.* The small test block, W_2, shall be 6.25±0.05 inches (158.8±1.3 mm) in diameter, approximately 2.8 inches (71 mm) high and shall weigh 8.5±0.1 lbs (3.86±0.05 kg).

2.7.3 *Large test block for conventional cooking top*. The large test block for the conventional cooking top, W_3, shall be 9±0.05 inches (228.6±1.3 mm) in diameter, approximately 3.0 inches (76 mm) high and shall weigh 19±0.1 lbs (8.62±0.05 kg).

2.7.4 *Thermocouple installation*. Install the thermocouple such that the thermocouple junction (where the thermocouple contacts the test block) is at the bottom of the hole provided in the test block and that the thermocouple junction makes good thermal contact with the aluminum block. If the test blocks are to be water cooled between tests the thermocouple hole should be sealed, or other steps taken, to insure that the thermocouple hole is completely dry at the start of the next test. Provide a temperature indicator system for measuring the test block temperature with an accuracy as indicated in Section 2.9.3.3.

2.7.5 *Initial test block temperature*. Maintain the initial temperature of the test blocks, T_I, within ±4 °F (±2.2 °C) of the ambient room air temperature as specified in Section 2.5. If the test block has been cooled (or heated) to bring it to room temperature, allow the block to stabilize for at least 2 minutes after removal from the cooling (or heating) source, before measuring its initial temperature.

2.8 [Reserved]

2.9 *Instrumentation*. Perform all test measurements using the following instruments, as appropriate:

2.9.1 *Electrical Measurements*.

2.9.1.1 *Watt-hour meter*. The watt-hour meter for measuring the electrical energy consumption of conventional ovens and cooking tops shall have a resolution of 1 watt-hour (3.6 kJ) or less and a maximum error no greater than 1.5 percent of the measured value for any demand greater than 100 watts.

2.9.1.2 *Watt meter*. The watt meter used to measure the conventional oven, conventional range, or range clock power shall have a resolution of 0.2 watt (0.2 J/s) or less and a maximum error no greater than 5 percent of the measured value.

2.9.1.3 *Standby mode and off mode watt meter*. The watt meter used to measure standby mode and off mode shall have a resolution as specified in Section 4, Paragraph 4.5 of IEC 62301 (incorporated by reference; see §430.3). The watt meter shall also be able to record a "true" average power as specified in Section 5, Paragraph 5.3.2(a) of IEC 62301.

2.9.2 *Gas Measurements*.

2.9.2.1 *Positive displacement meters*. The gas meter to be used for measuring the gas consumed by the gas burners of the oven or cooking top shall have a resolution of 0.01 cubic foot (0.28 L) or less and a maximum error no greater than 1 percent of the measured value for any demand greater than 2.2 cubic feet per hour (62.3 L/h). If a positive displacement gas meter is used for measuring the gas consumed by the pilot lights, it shall have a resolution of at least 0.01 cubic foot (0.28 L) or less and have a maximum error no greater than 2 percent of the measured value.

2.9.2.2 *Flow meter*. If a gas flow meter is used for measuring the gas consumed by the pilot lights, it shall be calibrated to have a maximum error no greater than 1.5 percent of the measured value and a resolution of 1 percent or less of the measured value.

2.9.3 *Temperature measurement equipment*.

2.9.3.1 *Room temperature indicating system*. The room temperature indicating system shall be as specified in Section 2.9.3.4 for ranges, ovens and cooktops.

2.9.3.2 *Temperature indicator system for measuring conventional oven temperature*. The equipment for measuring the conventional oven temperature shall have an error no greater than ±4 °F (±2.2 °C) over the range of 65° to 500 °F (18 °C to 260 °C).

2.9.3.3 *Temperature indicator system for measuring test block temperature*. The system shall have an error no greater than ±2 °F (±1.1 °C) when measuring specific temperatures over the range of 65° to 330 °F (18.3 °C to 165.6 °C). It shall also have an error no greater than ±2 °F (±1.1 °C) when measuring any temperature difference up to 240 °F (133.3 °C) within the above range.

2.9.3.4 *Temperature indicator system for measuring surface temperatures*. The temperature of any surface of an appliance shall be measured by means of a thermocouple in firm contact with the surface. The temperature indicating system shall have an error no greater than ±1 °F (±0.6°C) over the range 65° to 90 °F (18 °C to 32 °C).

2.9.4 *Heating Value*. The heating value of the natural gas or propane shall be measured with an instrument and associated readout device that has a maximum error no greater than ±0.5% of the measured value and a resolution of ±0.2% or less of the full scale reading of the indicator instrument. The heating value of natural gas or propane must be corrected for local temperature and pressure conditions.

2.9.5 *Scale*. The scale used for weighing the test blocks shall have a maximum error no greater than 1 ounce (28.4 g).

3. Test Methods and Measurements

3.1. *Test methods*.

3.1.1 *Conventional oven*. Perform a test by establishing the testing conditions set forth in section 2, "TEST CONDITIONS," of this appendix, and adjust any pilot lights of a conventional gas oven in accordance with the manufacturer's instructions and turn off the gas flow to the conventional cooking top, if so equipped. Before beginning the test, the conventional oven shall be at its normal nonoperating temperature as defined in section 1.7 and described in section 2.6. Set the conventional oven test block W_1 approximately in the center of the usable baking space. If there is a selector switch for selecting the mode of operation of the oven, set it for normal baking. If an oven permits baking by either forced convection by using a fan, or without forced convection, the oven is to be tested in each of those two modes. The oven shall remain on for at least one complete thermostat ''cut-off/cut-on'' of the electrical resistance heaters or gas burners after the test block temperature has increased 234 °F (130 °C) above its initial temperature.

3.1.1.1 *Self-cleaning operation of a conventional oven.* Establish the test conditions set forth in section 2, ''TEST CONDITIONS,'' of this appendix. Adjust any pilot lights of a conventional gas oven in accordance with the manufacturer's instructions and turn off the gas flow to the conventional cooking top. The temperature of the conventional oven shall be its normal nonoperating temperature as defined in section 1.7 and described in section 2.6. Then set the conventional oven's self-cleaning process in accordance with the manufacturer's instructions. If the self-cleaning process is adjustable, use the average time recommended by the manufacturer for a moderately soiled oven.

3.1.1.2 *Continuously burning pilot lights of a conventional gas oven.* Establish the test conditions set forth in Section 2, ''TEST CONDITIONS,'' of this appendix. Adjust any pilot lights of a conventional gas oven in accordance with the manufacturer's instructions and turn off the gas flow to the conventional cooking top. If a positive displacement gas meter is used the, test duration shall be sufficient to measure a gas consumption which is at least 200 times the resolution of the gas meter.

3.1.2 *Conventional cooking top.* Establish the test conditions set forth in section 2, ''TEST CONDITIONS,'' of this appendix. Adjust any pilot lights of a conventional gas cooking top in accordance with the manufacturer's instructions and turn off the gas flow to the conventional oven(s), if so equipped. The temperature of the conventional cooking top shall be its normal nonoperating temperature as defined in section 1.7 and described in section 2.6. Set the test block in the center of the surface unit under test. The small test block, W_2, shall be used on electric surface units of 7 inches (178 mm) or less in diameter. The large test block, W_3, shall be used on electric surface units over 7 inches (177.8 mm) in diameter and on all gas surface units. Turn on the surface unit under test and set its energy input rate to the maximum setting. When the test block reaches 144 °F (80 °C) above its initial test block temperature, immediately reduce the energy input rate to 25 ± 5 percent of the maximum energy input rate. After 15 ± 0.1 minutes at the reduced energy setting, turn off the surface unit under test.

3.1.2.1 *Continuously burning pilot lights of a conventional gas cooking top.* Establish the test conditions set forth in Section 2, ''TEST CONDITIONS,'' of this appendix. Adjust any pilot lights of a conventional gas cooking top in accordance with the manufacturer's instructions and turn off the gas flow to the conventional oven(s). If a positive displacement gas meter is used, the test duration shall be sufficient to measure a gas consumption which is at least 200 times the resolution of the gas meter.

3.1.3 *Microwave oven.*

3.1.3.1 *Microwave oven test standby mode and off mode power.* Establish the testing conditions set forth in section 2, ''TEST CONDITIONS,'' of this appendix. For microwave ovens that drop from a higher power state to a lower power state as discussed in Section 5, Paragraph 5.1, Note 1 of IEC 62301 (incorporated by reference; see section 430.3), allow sufficient time for the microwave oven to reach the lower power state before proceeding with the test measurement. Follow the test procedure as specified in Section 5, Paragraph 5.3 of IEC 62301. For units in which power varies as a function of displayed time in standby mode, set the clock time to 3:23 and use the average power approach described in Section 5, Paragraph 5.3.2(a), but with a single test period of 10 minutes +0/−2 sec after an additional stabilization period until the clock time reaches 3:33. If a microwave oven is capable of operation in either standby mode or off mode, as defined in sections 1.12 and 1.8, respectively, or both, test the microwave oven in each mode in which it can operate.

3.2 *Test measurements.*

3.2.1 *Conventional oven test energy consumption.* If the oven thermostat controls the oven temperature without cycling on and off, measure the energy consumed, E_O, when the temperature of the block reaches T_O (T_O is 234 °F (130 °C) above the initial block temperature, T_I). If the oven thermostat operates by cycling on and off, make the following series of measurements: Measure the block temperature, T_A, and the energy consumed, E_A, or volume of gas consumed, V_A, at the end of the last ''ON'' period of the conventional oven before the block reaches T_O. Measure the block temperature, T_B, and the energy consumed, E_B, or volume of gas consumed, V_B, at the beginning of the next ''ON'' period. Measure the block temperature, T_C, and the energy consumed, E_C, or volume of gas consumed, V_C, at the end of that ''ON'' period. Measure the block temperature, T_D, and the energy consumed, E_D, or volume of gas consumed, V_D, at the beginning of the following ''ON'' period. Energy measurements for E_O, E_A, E_B, E_C and E_D, should be expressed in watt-hours (kJ) for conventional electric ovens and volume measurements for V_A, V_B, V_C and V_D should be expressed in standard cubic feet (L) of gas for conventional gas ovens. For a gas oven, measure in watt-hours (kJ) any electrical energy, E_{IO}, consumed by an ignition device or other electrical components required for the operation of a conventional gas oven while heating the test block to T_O. The energy consumed by a continuously operating clock that is an integral part of the timing or temperature control circuit and cannot be disconnected during the test may be subtracted from the oven test energy to obtain the test energy consumption, E_O or E_{IO}.

3.2.1.1 *Conventional oven average test energy consumption.* If the conventional oven permits baking by either forced convection or without forced convection and the oven thermostat does not cycle on and off, measure the energy consumed with the forced convection mode, $(E_O)_1$, and without the forced convection mode, $(E_O)_2$, when the temperature of the block reaches T_O (T_O is 234 °F (130 °C) above the initial block temperature, T_I). If the conventional oven permits baking by either forced convection or without forced convection and the oven thermostat operates by cycling on and off, make the following series of measurements with and without the forced convection mode: Measure the block temperature, T_A, and the energy consumed, E_A, or volume of gas consumed, V_A, at the end of the last "ON" period of the conventional oven before the block reaches T_O. Measure the block temperature, T_B, and the energy consumed, E_B, or volume of gas consumed, V_B, at the beginning of the next "ON" period. Measure the block temperature, T_C, and the energy consumed, E_C, or volume of gas consumed, V_C, at the end of that "ON" period. Measure the block temperature, T_D, and the energy consumed, E_D, or volume of gas consumed, V_D, at the beginning of the following "ON" period. Energy measurements for E_O, E_A, E_B, E_C and E_D should be expressed in watt-hours (kJ) for conventional electric ovens and volume measurements for V_A, V_B, V_C and V_D should be expressed in standard cubic feet (L) of gas for conventional gas ovens. For a gas oven that can be operated with or without forced convection, measure in watt-hours (kJ) any electrical energy consumed by an ignition device or other electrical components required for the operation of a conventional gas oven while heating the test block to T_O using the forced convection mode, $(E_{IO})_1$, and without using the forced convection mode, $(E_{IO})_2$. The energy consumed by a continuously operating clock that is an integral part of the timing or temperature control circuit and cannot be disconnected during the test may be subtracted from the oven test energy to obtain the test energy consumption, $(E_O)_1$ and $(E_O)_2$ or $(E_{IO})_1$ and $(E_{IO})_2$.

3.2.1.2 *Energy consumption of self-cleaning operation.* Measure the energy consumption, E_S, in watt-hours (kJ) of electricity or the volume of gas consumption, V_S, in standard cubic feet (L) during the self-cleaning test set forth in Section 3.1.1.1. For a gas oven, also measure in watt-hours (kJ) any electrical energy, E_{IS}, consumed by ignition devices or other electrical components required during the self-cleaning test. The energy consumed by a continuously operating clock that is an integral part of the timing or temperature control circuit and cannot be disconnected during the test may be subtracted from the self-cleaning test energy to obtain the energy consumption, E_S or E_{IS}

3.2.1.3 *Gas consumption of continuously burning pilot lights.* Measure the gas consumption of the pilot lights, V_{OP}, in standard cubic feet (L) of gas and the test duration, t_{OP}, in hours for the test set forth in Section 3.1.1.2. If a gas flow rate meter is used, measure the flow rate, Q_{OP}, in standard cubic feet per hour (L/h).

3.2.1.4 *Clock power.* If the conventional oven or conventional range includes an electric clock which is on continuously, and the power rating in watts (J/s) of this feature is not known, measure the clock power, P_{CL}, in watts (J/s.) The power rating or measurement of continuously operating clocks, that are an integral part of the timing or temperature control circuits and cannot be disconnected during testing, shall be multiplied by the applicable test period to calculate the clock energy consumption, in watt-hours (kJ), during a test. The energy consumed by the clock during the test may then be subtracted from the test energy to obtain the specified test energy consumption value.

3.2.2 *Conventional surface unit test energy consumption.* For the surface unit under test, measure the energy consumption, E_{CT}, in watt-hours (kJ) of electricity or the volume of gas consumption, V_{CT}, in standard cubic feet (L) of gas and the test block temperature, T_{CT}, at the end of the 15 minute (reduced input setting) test interval for the test specified in Section 3.1.2 and the total time, t_{CT}, in hours, that the unit is under test. Measure any electrical energy, E_{IC}, consumed by an ignition device of a gas heating element in watt-hours (kJ). The energy consumed by a continuously operating clock that is an integral part of the timing or temperature control circuit and cannot be disconnected during the test may be subtracted from the cooktop test energy to obtain the test energy consumption, E_{CT} or E_{IC}.

3.2.2.1 *Gas consumption of continuously burning pilot lights.* If the conventional gas cooking top under test has one or more continuously burning pilot lights, measure the gas consumed during the test by the pilot lights, V_{CP}, in standard cubic feet (L) of gas, and the test duration, t_{CP}, in hours as specified in Section 3.1.2.1. If a gas flow rate meter is used, measure the flow rate, Q_{CP}, in standard cubic feet per hour (L/h).

3.2.3 *Microwave oven test standby mode and off mode power*. Make measurements as specified in Section 5, Paragraph 5.3 of IEC 62301 (incorporated by reference; see §430.3). If the microwave oven is capable of operating in standby mode, measure the average standby mode power of the microwave oven, P_{SB}, in watts as specified in section 3.1.3.1. If the microwave oven is capable of operating in off mode, measure the average off mode power of the microwave oven, P_{OFF}, as specified in section 3.1.3.1.

3.3 *Recorded values*.

3.3.1 Record the test room temperature, T_R, at the start and end of each range, oven or cooktop test, as determined in Section 2.5.

3.3.2 Record measured test block weights W_1, W_2, and W_3 in pounds (kg).

3.3.3 Record the initial temperature, T_1, of the test block under test.

3.3.4 For a conventional oven with a thermostat which operates by cycling on and off, record the conventional oven test measurements T_A, E_A, T_B, E_B, T_C, E_C, T_D, and E_D for conventional electric ovens or T_A, V_A, T_B, V_B, T_C, V_C, T_D, and V_D for conventional gas ovens. If the thermostat controls the oven temperature without cycling on and off, record E_O. For a gas oven which also uses electrical energy for the ignition or operation of the oven, also record E_{IO}.

3.3.5 For a conventional oven that can be operated with or without forced convection and the oven thermostat controls the oven temperature without cycling on and off, measure the energy consumed with the forced convection mode, $(E_O)_1$, and without the forced convection mode, $(E_O)_2$. If the conventional oven operates with or without forced convection and the thermostat controls the oven temperature by cycling on and off, record the conventional oven test measurements T_A, E_A, T_B, E_B, T_C, E_C, T_D, and E_D for conventional electric ovens or T_A, V_A, T_B, V_B, T_C, V_C, T_D, and V_D for conventional gas ovens. For a gas oven that can be operated with or without forced convection, measure any electrical energy consumed by an ignition device or other electrical components used during the forced convection mode, $(E_{IO})_1$, and without using the forced convection mode, $(E_{IO})_2$.

3.3.6 Record the measured energy consumption, E_S, or gas consumption, V_S, and for a gas oven, any electrical energy, E_{IS}, for the test of the self-cleaning operation of a conventional oven.

3.3.7 Record the gas flow rate, Q_{OP}; or the gas consumption, V_{OP}, and the elapsed time, t_{OP}, that any continuously burning pilot lights of a conventional oven are under test.

3.3.8 Record the clock power measurement or rating, P_{CL}, in watts (J/s), except for microwave oven tests.

3.3.9 For the surface unit under test, record the electric energy consumption, E_{CT}, or the gas volume consumption, V_{CT}, the final test block temperature, T_{CT}, the total test time, t_{CT}. For a gas cooking top which uses electrical energy for ignition of the burners, also record E_{IC}.

3.3.10 Record the gas flow rate, Q_{CP}; or the gas consumption, V_{CP}, and the elapsed time, t_{CP}, that any continuously burning pilot lights of a conventional gas cooking top are under test.

3.3.11 Record the heating value, H_n, as determined in Section 2.2.2.2 for the natural gas supply.

3.3.12 Record the heating value, H_p, as determined in Section 2.2.2.3 for the propane supply.

3.3.13 Record the average standby mode power, P_{SB}, for the microwave oven standby mode, as determined in section 3.2.3 for a microwave oven capable of operating in standby mode. Record the average off mode power, P_{OFF}, for the microwave oven off mode power test, as determined in section 3.2.3 for a microwave oven capable of operating in off mode.

4. Calculation of Derived Results From Test Measurements

4.1 *Conventional oven*.

4.1.1 *Test energy consumption*. For a conventional oven with a thermostat which operates by cycling on and off, calculate the test energy consumption, E_O, expressed in watt-hours (kJ) for electric ovens and in Btu's (kJ) for gas ovens, and defined as:

$$E_O = E_{AB} + \left[\left(\frac{T_O - T_{AB}}{T_{CD} - T_{AB}} \right) \times \left(E_{CD} - E_{AB} \right) \right]$$

for electric ovens, and,

$$E_O = (V_{AB} \times H) + \left[\left(\frac{T_O - T_{AB}}{T_{CD} - T_{AB}}\right) \times (V_{CD} - V_{AB}) \times H\right]$$

For gas ovens

Where:

H = either H_n or H_p, the heating value of the gas used in the test as specified in Section 2.2.2.2 and Section 2.2.2.3, expressed in Btu's per standard cubic foot (kJ/L).

T_O = 234 °F (130 °C) plus the initial test block temperature.

and,

$$E_{AB} = \frac{(E_A + E_B)}{2}, \quad E_{CD} = \frac{(E_C + E_D)}{2}$$

$$V_{AB} = \frac{(V_A + V_B)}{2}, \quad V_{CD} = \frac{(V_C + V_D)}{2}$$

$$T_{AB} = \frac{(T_A + T_B)}{2}, \quad T_{CD} = \frac{(T_C + T_D)}{2}$$

Where:

T_A = block temperature in °F (°C) at the end of the last "ON" period of the conventional oven before the test block reaches T_O.

T_B = block temperature in °F (°C) at the beginning of the "ON" period following the measurement of T_A.

T_C = block temperature in °F (°C) at the end of the "ON" period which starts with T_B.

T_D = block temperature in °F (°C) at the beginning of the "ON" period which follows the measurement of T_C.

E_A = electric energy consumed in Wh (kJ) at the end of the last "ON" period before the test block reaches T_O.

E_B = electric energy consumed in Wh (kJ) at the beginning of the "ON" period following the measurement of T_A.

E_C = electric energy consumed in Wh (kJ) at the end of the "ON" period which starts with T_B.

E_D = electric energy consumed in Wh (kJ) at the beginning of the "ON" period which follows the measurement of T_C.

V_A = volume of gas consumed in standard cubic feet (L) at the end of the last "ON" period before the test block reaches T_O.

V_B = volume of gas consumed in standard cubic feet (L) at the beginning of the "ON" period following the measurement of T_A.

V_C = volume of gas consumed in standard cubic feet (L) at the end of the "ON" period which starts with T_B.

V_D = volume of gas consumed in standard cubic feet (L) at the beginning of the "ON" period which follows the measurement of T_C.

The energy consumed by a continuously operating clock that cannot be disconnected during the test may be subtracted from the oven test energy to obtain the oven test energy consumption, E_O.

4.1.1.1 *Average test energy consumption.* If the conventional oven can be operated with or without forced convection, determine the average test energy consumption, E_O and E_{IO}, in watt-hours (kJ) for electric ovens and Btu's (kJ) for gas ovens using the following equations:

$$E_O = \frac{(E_O)_1 + (E_O)_2}{2}$$

$$E_{IO} = \frac{(E_{IO})_1 + (E_{IO})_2}{2}$$

Where:

$(E_O)_1$=test energy consumption using the forced convection mode in watt-hours (kJ) for electric ovens and in Btu's (kJ) for gas ovens as measured in Section 3.2.1.1.

$(E_O)_2$=test energy consumption without using the forced convection mode in watt-hours (kJ) for electric ovens and in Btu's (kJ) for gas ovens as measured in Section 3.2.1.1.

$(E_{IO})_1$=electrical energy consumption in watt-hours (kJ) of a gas oven in forced convection mode as measured in Section 3.2.1.1. $(E_{IO})_2$=electrical energy consumption in watt-hours (kJ) of a gas oven without using the forced convection mode as measured in Section 3.2.1.1.

The energy consumed by a continuously operating clock that cannot be disconnected during the test may be subtracted from the oven test energy to obtain the average test energy consumption E_O and E_{IO}.

4.1.2 *Conventional oven annual energy consumption.*

4.1.2.1. *Annual cooking energy consumption.*

4.1.2.1.1. *Annual primary energy consumption.* Calculate the annual primary energy consumption for cooking, E_{CO}, expressed in kilowatt-hours (kJ) per year for electric ovens and in Btu's (kJ) per year for gas ovens, and defined as:

$$E_{CO} = \frac{E_O \times K_e \times O_O}{W_1 \times C_p \times T_S} \text{ for electric ovens,}$$

Where:

E_O=test energy consumption as measured in Section 3.2.1 or as calculated in Section 4.1.1 or Section 4.1.1.1.

K_e=3.412 Btu/Wh (3.6 kJ/Wh,) conversion factor of watt-hours to Btu's.

O_O=29.3 kWh (105,480 kJ) per year, annual useful cooking energy output of conventional electric oven.

W_1=measured weight of test block in pounds (kg).

C_p=0.23 Btu/lb-°F (0.96 kJ/kg ÷ °C), specific heat of test block.

T_S=234 °F (130 °C), temperature rise of test block.

$$E_{CO} = \frac{E_O \times O_O}{W_1 \times C_p \times T_S} \text{ for gas ovens,}$$

Where:

E_O=test energy consumption as measured in Section 3.2.1. or as calculated in Section 4.1.1 or Section 4.1.1.1.

O_O=88.8 kBtu (93,684 kJ) per year, annual useful cooking energy output of conventional gas oven.

W_1, C_p and T_S are the same as defined above.

4.1.2.1.2 *Annual secondary energy consumption for cooking of gas ovens.* Calculate the annual secondary energy consumption for cooking, E_{SO}, expressed in kilowatt-hours (kJ) per year and defined as:

$$E_{SO} = \frac{E_{IO} \times K_e \times O_O}{W_1 \times C_p \times T_S},$$

Where:

E_{IO}=electrical test energy consumption as measured in Section 3.2.1 or as calculated in Section 4.1.1.1.

O_O=29.3 kWh (105,480 kJ) per year, annual useful cooking energy output.

K_e, W_1, C_p, and T_S are as defined in Section 4.1.2.1.1.

4.1.2.2 *Annual energy consumption of any continuously burning pilot lights.* Calculate the annual energy consumption of any continuously burning pilot lights, E_{PO}, expressed in Btu's (kJ) per year and defined as:

$E_{PO}=Q_{OP} \times H \times (A - B)$,

or,

$$E_{PO} = \frac{V_{OP}}{t_{OP}} \times H \times (A - B)$$

Where:

Q_{OP}=pilot gas flow rate in standard cubic feet per hour (L/h), as measured in Section 3.2.1.3.

V_{OP}=standard cubic feet (L) of gas consumed by any continuously burning pilot lights, as measured in Section 3.2.1.3.

t_{OP}=elapsed test time in hours for any continuously burning pilot lights tested, as measured in Section 3.2.1.3.

H=H_n or H_p, the heating value of the gas used in the test as specified in Section 2.2.2.2 and Section 2.2.2.3 in Btu's per standard cubic foot (kJ/L).

A=8,760, number of hours in a year.

B=300, number of hours per year any continuously burning pilot lights contribute to the heating of an oven for cooking food.

4.1.2.3 *Annual conventional oven self-cleaning energy.*

4.1.2.3.1 *Annual primary energy consumption.* Calculate the annual primary energy consumption for conventional oven self-cleaning operations, E_{SC}, expressed in kilowatt-hours (kJ) per year for electric ovens and in Btu's (kJ) for gas ovens, and defined as:

$E_{SC}=E_S \times S_e \times K$, for electric ovens,

Where:

E_S=energy consumption in watt-hours, as measured in Section 3.2.1.2.

S_e=4, average number of times a self-cleaning operation of a conventional electric oven is used per year.

K=0.001 kWh/Wh conversion factor for watt-hours to kilowatt-hours.

or

$E_{SC}=V_S \times H \times S_g$, for gas ovens,

Where:

V_S=gas consumption in standard cubic feet (L), as measured in Section 3.2.1.2.

H=H_n or H_p, the heating value of the gas used in the test as specified in Section 2.2.2.2 and Section 2.2.2.3 in Btu's per standard cubic foot (kJ/L).

S_g=4, average number of times a self-cleaning operation of a conventional gas oven is used per year.

The energy consumed by a continuously operating clock that cannot be disconnected during the self-cleaning test procedure may be subtracted from the test energy to obtain the test energy consumption, E_{SC}.

4.1.2.3.2 *Annual secondary energy consumption for self-cleaning operation of gas ovens.* Calculate the annual secondary energy consumption for self-cleaning operations of a gas oven, E_{SS}, expressed in kilowatt-hours (kJ) per year and defined as:

$E_{SS}=E_{IS} \times S_g \times K$,

Where:

E_{IS}=electrical energy consumed during the self-cleaning operation of a conventional gas oven, as measured in Section 3.2.1.2.

S_g=4, average number of times a self-cleaning operation of a conventional gas oven is used per year.

K=0.001 kWh/Wh conversion factor for watt-hours to kilowatt-hours.

4.1.2.4 *Annual clock energy consumption.* Calculate the annual energy consumption of any constantly operating electric clock, E_{CL}, expressed in kilowatt-hours (kJ) per year and defined as:

$E_{CL} = P_{CL} \times A \times K$,

Where:

P_{CL}=power rating of clock which is on continuously, in watts, as measured in Section 3.2.1.4.
A=8,760, number of hours in a year.
K=0.001 kWh/Wh conversion factor for watt-hours to kilowatt-hours.

4.1.2.5 *Total annual energy consumption of a single conventional oven.*

4.1.2.5.1 *Conventional electric oven energy consumption.* Calculate the total annual energy consumption of a conventional electric oven, E_{AO}, expressed in kilowatt-hours (kJ) per year and defined as:

$E_{AO}=E_{CO}+E_{SC}+E_{CL}$,

Where:

E_{CO}=annual primary cooking energy consumption as determined in Section 4.1.2.1.1.
E_{SC}=annual primary self-cleaning energy consumption as determined in Section 4.1.2.3.1.
E_{CL}=annual clock energy consumption as determined in Section 4.1.2.4.

4.1.2.5.2 *Conventional gas oven energy consumption.* Calculate the total annual gas energy consumption of a conventional gas oven, E_{AOG}, expressed in Btu's (kJ) per year and defined as:

$E_{AOG}=E_{CO}+E_{SC}+E_{PO}$,

Where:

E_{CO}=annual primary cooking energy consumption as determined in Section 4.1.2.1.1.
E_{PO}=annual pilot light energy consumption as determined in Section 4.1.2.2.
E_{SC}=annual primary self-cleaning energy consumption as determined in Section 4.1.2.3.1.

If the conventional gas oven uses electrical energy, calculate the total annual electrical energy consumption, E_{AOE}, expressed in kilowatt-hours (kJ) per year and defined as:

$E_{AOE}=E_{SO}+E_{SS}+E_{CL}$,

Where:

E_{SO}=annual secondary cooking energy consumption as determined in Section 4.1.2.1.2.
E_{SS}=annual secondary self-cleaning energy consumption as determined in Section 4.1.2.3.2.
E_{CL}=annual clock energy consumption as determined in Section 4.1.2.4.

4.1.2.6. *Total annual energy consumption of multiple conventional ovens.* If the cooking appliance includes more than one conventional oven, calculate the total annual energy consumption of the conventional ovens using the following equations:

4.1.2.6.1 *Conventional electric oven energy consumption.* Calculate the total annual energy consumption, ETO, in kilowatt-hours (kJ) per year and defined as:

$E_{TO} = E_{ACO} + E_{ASC} + E_{CL}$,

Where:

$$E_{ACO} = \frac{1}{n}\sum_{i=1}^{n}\left(E_{CO}\right)_i,$$

is the average annual primary energy consumption for cooking,

and where:

n = number of conventional ovens in the basic model.
E_{CO} = annual primary energy consumption for cooking as determined in Section 4.1.2.1.1.

$$E_{ASC} = \frac{1}{n}\sum_{i=1}^{n}\left(E_{SC}\right)_i,$$

average annual self-cleaning energy consumption,
Where:

n = number of self-cleaning conventional ovens in the basic model.
E_{SC} = annual primary self-cleaning energy consumption as determined according to Section 4.1.2.3.1.
E_{CL} = clock energy consumption as determined according to Section 4.1.2.4.

4.1.2.6.2 *Conventional gas oven energy consumption.* Calculate the total annual gas energy consumption, E_{TOG}, in Btu's (kJ) per year and defined as:

$E_{TOG} = E_{ACO} + E_{ASC} + E_{TPO}$,

Where:

E_{ACO} = average annual primary energy consumption for cooking in Btu's (kJ) per year and is calculated as:

$$E_{ACO} = \frac{1}{n}\sum_{i=1}^{n}\left(E_{CO}\right)_i,$$

Where:

n = number of conventional ovens in the basic model.
E_{CO} = annual primary energy consumption for cooking as determined in Section 4.1.2.1.1.

and,

E_{ASC} = average annual self-cleaning energy consumption in Btu's (kJ) per year and is calculated as:

$$E_{ASC} = \frac{1}{n}\sum_{i=1}^{n}\left(E_{SC}\right)_i,$$

Where:

n = number of self-cleaning conventional ovens in the basic model.

E_{SC} = annual primary self-cleaning energy consumption as determined according to Section 4.1.2.3.1.

$$E_{TPO} = \sum_{i=1}^{n}\left(E_{PO}\right)_i,$$

total energy consumption of any pilot lights,

Where:

E_{PO} = annual energy consumption of any continuously burning pilot lights determined according to Section 4.1.2.2.

n = number of pilot lights in the basic model.

If the oven also uses electrical energy, calculate the total annual electrical energy consumption, E_{TOE}, in kilowatt-hours (kJ) per year and defined as:

$E_{TOE} = E_{ASO} + E_{AAS} + E_{CL}$,

Where:

$$E_{ASO} = \frac{1}{n}\sum_{i=1}^{n}\left(E_{SO}\right)_i,$$

is the average annual secondary energy consumption for cooking,

Where:

n=number of conventional ovens in the basic model.

E_{SO}=annual secondary energy consumption for cooking of gas ovens as determined in Section 4.1.2.1.2.

$$E_{AAS} = \frac{1}{n}\sum_{i=1}^{n}\left(E_{SS}\right)_i,$$

is the average annual secondary self-cleaning energy consumption,

Where:

n=number of self-cleaning ovens in the basic model.

E_{SS}=annual secondary self-cleaning energy consumption of gas ovens as determined in Section 4.1.2.3.2.

E_{CL}=annual clock energy consumption as determined in Section 4.1.2.4.

4.1.3 *Conventional oven cooking efficiency.*

4.1.3.1 *Single conventional oven.* Calculate the conventional oven cooking efficiency, Eff_{AO}, using the following equations:

For electric ovens:

$$Eff_{AO} = \frac{W_1 \times C_p \times T_S}{E_O \times K_e},$$

and,

For gas ovens:

$$Eff_{AO} = \frac{W_1 \times C_p \times T_S}{E_O + \left(E_{IO} \times K_e\right)},$$

Where:

W_1=measured weight of test block in pounds (kg).

C_p=0.23 Btu/lb-°F (0.96 kJ/kg÷ °C), specific heat of test block.

T_S=234 °F (130 °C), temperature rise of test block.

E_O=test energy consumption as measured in Section 3.2.1 or calculated in Section 4.1.1 or Section 4.1.1.1.

K_e=3.412 Btu/Wh (3.6 kJ/Wh), conversion factor for watt-hours to Btu's.

E_{IO}=electrical test energy consumption according to Section 3.2.1 or as calculated in Section 4.1.1.1.

4.1.3.2 *Multiple conventional ovens.* If the cooking appliance includes more than one conventional oven, calculate the cooking efficiency for all of the conventional ovens in the appliance, Eff_{TO}, using the following equation:

$$Eff_{TO} = \frac{n}{\sum_{i=1}^{n}\left(\frac{1}{Eff_{AO}}\right)_i},$$

Where:

n=number of conventional ovens in the cooking appliance.

Eff_{AO}=cooking efficiency of each oven determined according to Section 4.1.3.1.

4.1.4 *Conventional oven energy factor.* Calculate the energy factor, or the ratio of useful cooking energy output to the total energy input, R_O, using the following equations:

$$R_O = \frac{O_O}{E_{AO}},$$

For electric ovens,

Where:

O_O=29.3 kWh (105,480 kJ) per year, annual useful cooking energy output.

E_{AO}=total annual energy consumption for electric ovens as determined in Section 4.1.2.5.1.

For gas ovens:

$$R_O = \frac{O_O}{E_{AOG} + \left(E_{AOE} \times K_e\right)},$$

Where:

O_O=88.8 kBtu (93,684 kJ) per year, annual useful cooking energy output.

E_{AOG}=total annual gas energy consumption for conventional gas ovens as determined in Section 4.1.2.5.2.

E_{AOE}=total annual electrical energy consumption for conventional gas ovens as determined in Section 4.1.2.5.2.

K_e=3,412 Btu/kWh (3,600 kJ/kWh), conversion factor for kilowatt-hours to Btu's.

4.2 *Conventional cooking top*

4.2.1 *Conventional cooking top cooking efficiency*

4.2.1.1 *Electric surface unit cooking efficiency*. Calculate the cooking efficiency, Eff_{SU}, of the electric surface unit under test, defined as:

$$Eff_{SU} = W \times C_p \times \left(\frac{T_{SU}}{K_e \times E_{CT}}\right),$$

Where:

W=measured weight of test block, W_2 or W_3, expressed in pounds (kg).

C_p=0.23 Btu/lb-°F (0.96 kJ/kg÷ °C), specific heat of test block.

T_{SU}=temperature rise of the test block: final test block temperature, T_{CT}, as determined in Section 3.2.2, minus the initial test block temperature, T_I, expressed in °F (°C) as determined in Section 2.7.5.

K_e=3.412 Btu/Wh (3.6 kJ/Wh), conversion factor of watt-hours to Btu's.

E_{CT}=measured energy consumption, as determined according to Section 3.2.2, expressed in watt-hours (kJ).

The energy consumed by a continuously operating clock that cannot be disconnected during the cooktop test may be subtracted from the energy consumption, E_{CT}, as determined in Section 3.2.2.

4.2.1.2 *Gas surface unit cooking efficiency*. Calculate the cooking efficiency, Eff_{SU}, of the gas surface unit under test, defined as:

$$Eff_{SU} = \frac{W_3 \times C_P \times T_{SU}}{E},$$

Where:

W_3=measured weight of test block as measured in Section 3.3.2, expressed in pounds (kg).

C_p and T_{SU} are the same as defined in Section 4.2.1.1.

and,

$E=[V_{CT} - V_{CP}\times H] + (E_{IC}\times K_e)$,

Where:

V_{CT}=total gas consumption in standard cubic feet (L) for the gas surface unit test as measured in Section 3.2.2.

E_{IC}=electrical energy consumed in watt-hours (kJ) by an ignition device of a gas surface unit as measured in Section 3.2.2.

K_e=3.412 Btu/Wh (3.6 kJ/Wh), conversion factor of watt-hours to Btu's.

H=either H_n or H_p, the heating value of the gas used in the test as specified in Section 2.2.2.2 and Section 2.2.2.3, expressed in Btu's per standard cubic foot (kJ/L) of gas.

$V_{CP}=Q_{CP}\times t_{CT}$, pilot consumption, in standard cubic feet (L), during unit test,

Where:

t_{CT}=the elapsed test time as defined in Section 3.2.2.

and

$$Q_{CP} = \frac{V_{CP}}{t_{CP}},$$

(pilot flow in standard cubic feet per hour)

Where:

V_{CP}=any pilot lights gas consumption defined in Section 3.2.2.1.

t_{CP}=elapsed time of the cooking top pilot lights test as defined in Section 3.2.2.1.

4.2.1.3 *Conventional cooking top cooking efficiency*. Calculate the conventional cooking top cooking efficiency, Eff_{CT}, using the following equation:

$$Eff_{CT} = \frac{1}{n}\sum_{i=1}^{n}\left(Eff_{SU}\right)_i,$$

Where:

n=number of surface units in the cooking top.

Eff_{SU}=the efficiency of each of the surface units, as determined according to Section 4.2.1.1 or Section 4.2.1.2.

4.2.2 *Conventional cooking top annual energy consumption*.

4.2.2.1 *Conventional electric cooking top energy consumption*. Calculate the annual energy consumption of an electric cooking top, E_{CA}, in kilowatt-hours (kJ) per year, defined as:

$$E_{CA} = \frac{O_{CT}}{Eff_{CT}},$$

Where:

O_{CT}=173.1 kWh (623,160 kJ) per year, annual useful cooking energy output.

Eff_{CT}=conventional cooking top cooking efficiency as defined in Section 4.2.1.3.

4.2.2.2 *Conventional gas cooking top*

4.2.2.2.1 *Annual cooking energy consumption.* Calculate the annual energy consumption for cooking, E_{CC}, in Btu's (kJ) per year for a gas cooking top, defined as:

$$E_{CC} = \frac{O_{CT}}{Eff_{CT}},$$

Where:

O_{CT}=527.6 kBtu (556,618 kJ) per year, annual useful cooking energy output.

Eff_{CT}=the gas cooking top efficiency as defined in Section 4.2.1.3.

4.2.2.2.2 *Annual energy consumption of any continuously burning gas pilots.* Calculate the annual energy consumption of any continuously burning gas pilot lights of the cooking top, E_{PC}, in Btu's (kJ) per year, defined as:

E_{PC}=Q_{CP}×A×H,

Where:

Q_{CP}=pilot light gas flow rate as measured in Section 3.2.2.1.

A=8,760 hours, the total number of hours in a year.

H=either H_n or H_p, the heating value of the gas used in the test as specified in Section 2.2.2.2. and Section 2.2.2.3, expressed in Btu's per standard cubic foot (kJ/L) of gas.

4.2.2.2.3 *Total annual energy consumption of a conventional gas cooking top.* Calculate the total annual energy consumption of a conventional gas cooking top, E_{CA}, in Btu's (kJ) per year, defined as:

E_{CA}=E_{CC} + E_{PC},

Where:

E_{CC}=energy consumption for cooking as determined in Section 4.2.2.2.1.

E_{PC}=annual energy consumption of the pilot lights as determined in Section 4.2.2.2.2.

4.2.3 *Conventional cooking top energy factor.* Calculate the energy factor or ratio of useful cooking energy output for cooking to the total energy input, R_{CT}, as follows:

For an electric cooking top, the energy factor is the same as the cooking efficiency as determined according to Section 4.2.1.3.

For gas cooking tops,

$$R_{CT} = \frac{O_{CT}}{E_{CA}},$$

Where:

O_{CT}=527.6 kBtu (556,618 kJ) per year, annual useful cooking energy output of cooking top.

E_{CA}=total annual energy consumption of cooking top determined according to Section 4.2.2.2.3.

4.3 *Combined components.* The annual energy consumption of a kitchen range, *e.g.* a cooktop and oven combined, shall be the sum of the annual energy consumption of each of its components. The annual energy consumption for other combinations of ovens and cooktops will also be treated as the sum of the annual energy consumption of each of its components. The energy factor of a combined component is the sum of the annual useful cooking energy output of each component divided by the sum of the total annual energy consumption of each component.

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APPENDIX J TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF AUTOMATIC AND SEMI-AUTOMATIC CLOTHES WASHERS

The provisions of this appendix J shall apply to products manufactured after April 13, 2001. The procedures and calculations in sections 3.3, 4.3, and 4.4 of this appendix need not be performed to determine compliance with the energy conservation standards for clothes washers.

1. Definitions

1.1 *Adaptive control system* means a clothes washer control system, other than an adaptive water fill control system, which is capable of automatically adjusting washer operation or washing conditions based on characteristics of the clothes load placed in the clothes container, without allowing or requiring consumer intervention or actions. The automatic adjustments may, for example, include automatic selection, modification, or control of any of the following: wash water temperature, agitation or tumble cycle time, number of rinse cycles, and spin speed. The characteristics of the clothes load, which could trigger such adjustments, could, for example, consist of or be indicated by the presence of either soil, soap, suds, or any other additive laundering substitute or complementary product.

NOTE: Appendix J does not provide a means for determining the energy consumption of a clothes washer with an adaptive control system. Therefore, pursuant to 10 CFR 430.27, a waiver must be obtained to establish an acceptable test procedure for each such clothes washer.

1.2 *Adaptive water fill control system* means a clothes washer water fill control system which is capable of automatically adjusting the water fill level based on the size or weight of the clothes load placed in the clothes container, without allowing or requiring consumer intervention and/or actions.

1.3 *Bone-dry* means a condition of a load of test cloth which has been dried in a dryer at maximum temperature for a minimum of 10 minutes, removed and weighed before cool down, and then dried again for 10-minute periods until the final weight change of the load is 1 percent or less.

1.4 *Clothes container* means the compartment within the clothes washer that holds the clothes during operation of the machine.

1.5 *Compact* means a clothes washer which has a clothes container capacity of less than 1.6 ft^3 (45 L).

1.6 *Deep rinse cycle* means a rinse cycle in which the clothes container is filled with water to a selected level and the clothes load is rinsed by agitating it or tumbling it through the water.

1.7 *Front-loader clothes washer* means a clothes washer which sequentially rotates or tumbles portions of the clothes load above the water level allowing the clothes load to fall freely back into the water. The principal axis of the clothes container is in a horizontal plane and the access to the clothes container is through the front of the machine.

1.8 *Lockout* means that at least one wash/rinse water temperature combination is not available in the normal cycle that is available in another cycle on the machine.

1.9 *Make-up water* means the amount of fresh water needed to supplement the amount of stored water pumped from the external laundry tub back into the clothes washer when the suds-return feature is activated in order to achieve the required water fill level in the clothes washer.

1.10 *Modified energy factor* means the quotient of the cubic foot (or liter) capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water energy consumption, and the energy required for removal of the remaining moisture in the wash load.

1.11 *Most energy intensive cycle* means the non-normal cycle that uses the most energy for a given wash/rinse temperature combination.

1.12 *Non-normal cycle* means a cycle other than the normal cycle, but does not include any manually selected pre-wash, pre-soak, and extra-rinse option.

1.13 *Nonwater-heating clothes washer* means a clothes washer which does not have an internal water heating device to generate hot water.

1.14 *Normal cycle* means the cycle recommended by the manufacturer for washing cotton and/or linen clothes.

1.15 *Sensor filled* means a water fill control which automatically terminates the fill when the water reaches an appropriate level in the tub.

1.16 *Spray rinse cycle* means a rinse cycle in which water is sprayed onto the clothes load for a definite period of time without maintaining any specific water level in the clothes container.

1.17 *Standard* means a clothes washer which has a clothes container capacity of 1.6 ft^3 (45 L) or greater.

1.18 *Suds-return* means a feature or option on a clothes washer which causes the stored wash water obtained by utilizing the suds-saver feature to be pumped from the external laundry tub back into the clothes washer.

1.19 *Suds-saver* means a feature or option on a clothes washer which allows the user to store used wash water in an external laundry tub for use with subsequent wash loads.

1.20 *Temperature use factor* means the percentage of the total number of washes a user would wash with a particular wash/rinse temperature setting.

1.21 *Thermostatically controlled water valves* means clothes washer controls that have the ability to sense and adjust the hot and cold supply water.

1.22 *Time filled* means a water fill control which uses a combination of water flow controls in conjunction with time to terminate the water fill cycle.

1.23 *Top-loader-horizontal-axis clothes washer* means a clothes washer which: rotates or tumbles portions of the clothes load above the water level allowing the clothes load to fall freely back into the water with the principal axis in a horizontal plane and has access to the clothes container through the top of the clothes washer.

1.24 *Top-loader-vertical-axis clothes washer* means a clothes washer that: flexes and oscillates the submerged clothes load through the water by means of mechanical agitation or other movement; has a clothes container with the principal axis in a vertical plane; and has access to the clothes container through the top of the clothes washer.

1.25 *Water consumption factor* means the quotient of the total weighted per-cycle water consumption divided by the capacity of the clothes washer.

1.26 *Water-heating clothes washer* means a clothes washer where some or all of the hot water for clothes washing is generated by a water heating device internal to the clothes washer.

2. Testing Conditions

2.1 *Installation*. Install the clothes washer in accordance with manufacturer's instructions.

2.2 *Electrical energy supply*. Maintain the electrical supply at the clothes washer terminal block within 2 percent of 120, 120/240 or 120/208Y volts as applicable to the particular terminal block wiring system as specified by the manufacturer. If the clothes washer has a dual voltage conversion capability, conduct the test at the highest voltage specified by the manufacturer.

2.3 *Supply water*. For nonwater-heating clothes washers not equipped with thermostatically controlled water valves, the temperature of the hot and cold water supply shall be maintained at 100 °F±10 °F (37.8 °C±5.5 °C). For nonwater-heating clothes washers equipped with thermostatically controlled water valves, the temperature of the hot water supply shall be maintained at 140 °F±5 °F (60.0 °C±2.8 °C) and the cold water supply shall be maintained at 60 °F±5 °F (15.6 °C±2.8 °C). For water-heating clothes washers, the temperature of the hot water supply shall be maintained at 140 °F±5 °F (60.0 °C±2.8 °C) and the cold water supply shall not exceed 60 °F (15.6 °C). Water meters shall be installed in both the hot and cold water lines to measure water consumption.

2.3.1 *Supply water requirements for water and energy consumption testing*. For nonwater-heating clothes washers not equipped with thermostatically controlled water valves, the temperature of the hot and cold water supply shall be maintained at 100° ±10 °F (37.8 °C ±5.5 °C). For nonwater-heating clothes washers equipped with thermostatically controlled water valves, the temperature of the hot water supply shall be maintained at 140 °F ±5 °F (60.0 °C ±2.8 °C) and the cold water supply shall be maintained at 60 °F ±5F° (15.6 °C ±2.8 °C). For water-heating clothes washers, the temperature of the hot water supply shall be maintained at 140 °F ±5 °F (60.0 °C ±2.8 °C) and the cold water supply shall not exceed 60 °F (15.6 °C). Water meters shall be installed in both the hot and cold water lines to measure water consumption.

2.3.2 *Supply water requirements for remaining moisture content testing*. For nonwater-heating clothes washers not equipped with thermostatically controlled water valves, the temperature of the hot water supply shall be maintained at 140 °F ±5 °F and the cold water supply shall be maintained at 60 °F ±5 °F. All other clothes washers shall be connected to water supply temperatures as stated in 2.3.1 of this appendix.

2.4 *Water pressure*. The static water pressure at the hot and cold water inlet connections of the machine shall be maintained during the test at 35 pounds per square inch gauge (psig)±2.5 psig (241.3 kPa±17.2 kPa). The static water pressure for a single water inlet connection shall be maintained during the test at 35 psig±2.5 psig (241.3 kPa±17.2 kPa). Water pressure gauges shall be installed in both the hot and cold water lines to measure water pressure.

2.5 *Instrumentation*. Perform all test measurements using the following instruments, as appropriate:

2.5.1 *Weighing scales*.

2.5.1.1 *Weighing scale for test cloth*. The scale shall have a resolution no larger than 0.2 oz (5.7 g) and a maximum error no greater than 0.3 percent of the measured value.

2.5.1.2 *Weighing scale for clothes container capacity measurements*. The scale should have a resolution no larger than 0.50 lbs (0.23 kg) and a maximum error no greater than 0.5 percent of the measured value.

2.5.2 *Watt-hour meter*. The watt-hour meter shall have a resolution no larger than 1 Wh (3.6 kJ) and a maximum error no greater than 2 percent of the measured value for any demand greater than 50 Wh (180.0 kJ).

2.5.3 *Temperature measuring device*. The device shall have an error no greater than ±1 °F (±0.6 °C) over the range being measured.

2.5.4 *Water meter*. The water meter shall have a resolution no larger than 0.1 gallons (0.4 liters) and a maximum error no greater than 2 percent for all water flow rates from 1 gal/min (3.8 L/min) to 5 gal/min (18.9 L/min).

2.5.5 *Water pressure gauge*. The water pressure gauge shall have a resolution no larger than 1 psig (6.9 kPa) and shall have an error no greater than 5 percent of any measured value over the range of 32.5 psig (224.1 kPa) to 37.5 psig (258.6 kPa).

2.6 *Test cloths*.

2.6.1 *Energy test cloth*. The energy test cloth shall be clean and consist of the following:

2.6.1.1 Pure finished bleached cloth, made with a momie or granite weave, which is 50 percent cotton and 50 percent polyester and weighs 5.75 oz/yd^2 (195.0 g/m^2) and has 65 ends on the warp and 57 picks on the fill.

2.6.1.2 Cloth material that is 24 in by 36 in (61.0 cm by 91.4 cm) and has been hemmed to 22 in by 34 in (55.9 cm by 86.4 cm) before washing. The maximum shrinkage after five washes shall not be more than four percent on the length and width.

2.6.1.3 The number of test runs on the same energy test cloth shall not exceed 60 test runs. All energy test cloth must be permanently marked identifying the lot number of the material. Mixed lots of material shall not be used for testing the clothes washers.

2.6.2 *Energy Stuffer Cloth*. The energy stuffer cloths shall be made from energy test cloth material and shall consist of pieces of material that are 12 inches by 12 inches (30.5 cm by 30.5 cm) and have been hemmed to 10 inches by 10 inches (25.4 cm by 25.4 cm) before washing. The maximum shrinkage after five washes shall not be more than four percent on the length and width. The number of test runs on the same energy suffer cloth shall not exceed 60 test runs. All energy stuffer cloth must be permanently marked identifying the lot number of the material. Mixed lots of material shall not be used for testing the clothes washers.

2.7 *Composition of test loads*.

2.7.1 *Seven pound test load*. The seven pound test load shall consist of bone-dry energy test cloths which weigh 7 lbs ±0.07 lbs (3.18 kg ±0.03 kg). Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths.

2.7.2 *Three pound test load*. The three pound test load shall consist of bone-dry energy test cloths which weigh 3 lbs ±0.03 lbs (1.36 kg ±0.014 kg). Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths.

2.8 *Use of test loads*.

2.8.1 For a standard size clothes washer, a seven pound load, as described in section 2.7.1, shall be used to test the maximum water fill and a three pound test load, as described in section 2.7.2, shall be used to test the minimum water fill.

2.8.2 For a compact size clothes washer, a three pound test load as described in section 2.7.2 shall be used to test the maximum and minimum water fill levels.

2.8.3 A vertical-axis clothes washer without adaptive water fill control system also shall be tested without a test load for purposes of calculating the energy factor.

2.8.4 The test load sizes to be used to measure remaining moisture content (RMC) are specified in section 3.3.2.

2.8.5 Load the energy test cloths by grasping them in the center, shaking them to hang loosely and then dropping them into the clothes container prior to activating the clothes washer.

2.9 *Preconditioning*. If the clothes washer has not been filled with water in the preceding 96 hours, pre-condition it by running it through a cold rinse cycle and then draining it to ensure that the hose, pump, and sump are filled with water.

2.10 *Wash time (period of agitation or tumble) setting*. If the maximum available wash time in the normal cycle is greater than 9.75 minutes, the wash time shall be not less than 9.75 minutes. If the maximum available wash time in the normal cycle is less than 9.75 minutes, the wash time shall be the maximum available wash time.

2.11 *Agitation speed and spin speed settings*. Where controls are provided for agitation speed and spin speed selections, set them as follows:

2.11.1 For energy and water consumption tests, set at the normal cycle settings. If settings at the normal cycle are not offered, set the control settings to the maximum speed permitted on the clothes washer.

2.11.2 For remaining moisture content tests, see section 3.3.

3. Test Measurements

3.1 *Clothes container capacity*. Measure the entire volume which a dry clothes load could occupy within the clothes container during washer operation according to sections 3.1.1 through 3.1.5.

3.1.1 Place the clothes washer in such a position that the uppermost edge of the clothes container opening is leveled horizontally, so that the container will hold the maximum amount of water.

3.1.2 Line the inside of the clothes container with 2 mil (0.051 mm) plastic sheet. All clothes washer components which occupy space within the clothes container and which are recommended for use with the energy test cycle shall be in place and shall be lined with 2 mil (0.051 mm) plastic sheet to prevent water from entering any void space.

3.1.3 Record the total weight of the machine before adding water.

3.1.4 Fill the clothes container manually with either 60 °F ±5 °F (15.6 °C ±2.8 °C) or 100 °F ±10 °F (37.8 °C ±5.5 °C) water to its uppermost edge. Measure and record the weight of water, W, in pounds.

3.1.5 The clothes container capacity is calculated as follows:

$$C=W/d.$$

where:

C=Capacity in cubic feet (or liters).

W=Mass of water in pounds (or kilograms).

d=Density of water (62.0 lbs/ft^3 for 100 °F (993 kg/m^3 for 37.8 °C) or 62.3 lbs/ft^3 for 60 °F (998 kg/m^3 for 15.6 °C)).

3.2 *Test cycle*. Establish the test conditions set forth in section 2 of this appendix.

3.2.1 A clothes washer that has infinite temperature selections shall be tested at the following temperature settings: hottest setting available on the machine, hot (a minimum of 140 °F (60.0 °C) and a maximum of 145 °F (62.8 °C)), warm (a minimum of 100 °F (37.8 °C) and a maximum of 105 °F (40.6 °C)), and coldest setting available on the machine. These temperatures must be confirmed by measurement using a temperature measuring device. If the measured final water temperature is not within the specified range, stop testing, adjust the temperature selector accordingly, and repeat the procedure.

3.2.2 *Clothes washers with adaptive water fill control system and/or unique temperature selections*.

3.2.2.1 *Clothes washers with adaptive water fill control system*. When testing a clothes washer that has adaptive water fill control, the maximum and the minimum test loads as specified in 2.8.1 and 2.8.2 shall be used. The amount of water fill shall be determined by the control system. If the clothes washer provides consumer selection of variable water fill amounts for the adaptive water fill control system, two complete sets of tests shall be conducted. The first set of tests shall be conducted with the adaptive water fill control system set in the setting that will use the greatest amount of energy. The second set of tests shall be conducted with the adaptive water fill control system set in the setting that will use the smallest amount of energy. Then, the results from these two tests shall be averaged to determine the adaptive water fill energy consumption value. If a clothes washer with an adaptive water fill control system allows consumer selection of manual controls as an alternative, both the manual and adaptive modes shall be tested and the energy consumption values, E_T, M_E, and D_E (if desired), calculated in section 4 for each mode, shall be averaged between the manual and adaptive modes.

3.2.2.2 *Clothes washers with multiple warm wash temperature combination selections.*

3.2.2.2.1 If a clothes washer's temperature combination selections are such that the temperature of each warm wash setting that is above the mean warm wash temperature (the mean temperature of the coldest and warmest warm settings) is matched by a warm wash setting that is an equal distance below the mean, then the energy test shall be conducted at the mean warm wash temperature if such a selection is provided, or if there is no position on the control that permits selection of the mean temperature, the energy test shall be conducted with the temperature selection set at the next hotter temperature setting that is available above the mean.

3.2.2.2.2 If the multiple warm wash temperature combination selections do not meet criteria in section 3.2.2.2.1, the energy test shall be conducted with the temperature selection set at the warm wash temperature setting that gives the next higher water temperature than the mean temperature of the coldest and warmest warm settings.

3.2.2.3 *Clothes washers with multiple temperature settings within a temperature combination selection.* When a clothes washer is provided with a secondary control that can modify the wash or rinse temperature within a temperature combination selection, the secondary control shall be set to provide the hottest wash temperature available and the hottest rinse temperature available. For instance, when the temperature combination selection is set for the middle warm wash temperature and a secondary control exists which allows this temperature to be increased or decreased, the secondary control shall be set to provide the hottest warm wash temperature available for the middle warm wash setting.

3.2.3 *Clothes washers that do not lockout any wash/rinse temperature combinations in the normal cycle.* Test in the normal cycle all temperature combination selections that are required to be tested.

3.2.3.1 *Hot water consumption, cold water consumption, and electrical energy consumption at maximum fill.* Set the water level selector at maximum fill available on the clothes washer, if manually controlled, and insert the appropriate test load, if applicable. Activate the normal cycle of the clothes washer and also any suds-saver switch.

3.2.3.1.1 For automatic clothes washers, set the wash/rinse temperature selector to the hottest temperature combination setting. For semi-automatic clothes washers, open the hot water faucet valve completely and close the cold water faucet valve completely to achieve the hottest temperature combination setting.

3.2.3.1.2 Measure the electrical energy consumption of the clothes washer for the complete cycle.

3.2.3.1.3 Measure the respective number of gallons (or liters) of hot and cold water used to fill the tub for the wash cycle.

3.2.3.1.4 Measure the respective number of gallons (or liters) of hot and cold water used for all deep rinse cycles.

3.2.3.1.5 Measure the respective gallons (or liters) of hot and cold water used for all spray rinse cycles.

3.2.3.1.6 For non-water-heating automatic clothes washers repeat sections 3.2.3.1.3 through 3.2.3.1.5 for each of the other wash/rinse temperature selections available that uses heated water and is required to be tested. For water-heating clothes washers, repeat sections 3.2.3.1.2 through 3.2.3.1.5 for each of the other wash/rinse temperature selections available that uses heated water and is required to be tested. (When calculating water consumption under section 4.3 for any machine covered by the previous two sentences, also test the cold wash/cold rinse selection.) For semi-automatic clothes washers, repeat sections 3.2.3.1.3 through 3.2.3.1.5 for the other wash/rinse temperature settings in section 6 with the following water faucet valve adjustments:

	Faucet position	
	Hot valve	Cold valve
Hot	Completely open	Closed.
Warm	Completely open	Completely open.
Cold	Closed	Completely open.

3.2.3.1.7 If the clothes washer is equipped with a suds-saver cycle, repeat sections 3.2.3.1.2 to 3.2.3.1.5 with suds-saver switch set to suds return for the Warm/Cold temperature setting.

3.2.3.2 *Hot water consumption, cold water consumption, and electrical energy consumption with the water level selector at minimum fill.* Set the water level selector at minimum fill, if manually controlled, and insert the appropriate test load, if applicable. Activate the normal cycle of the clothes washer and also any suds-saver switch. Repeat sections 3.2.3.1.1 through 3.2.3.1.7.

3.2.3.3 *Hot and cold water consumption for clothes washers that incorporate a partial fill during the rinse cycle.* For clothes washers that incorporate a partial fill during the rinse cycle, activate any suds-saver switch and operate the clothes washer for the complete normal cycle at both the maximum water fill level and the minimum water fill level for each of the wash/rinse temperature selections available. Measure the respective hot and cold water consumed during the complete normal cycle.

3.2.4 *Clothes washers that lockout any wash/rinse temperature combinations in the normal cycle.* In addition to the normal cycle tests in section 3.2.3, perform the following tests on non-normal cycles for each wash/rinse temperature combination selection that is locked out in the normal cycle.

3.2.4.1 Set the cycle selector to a non-normal cycle which has the wash/rinse temperature combination selection that is locked out. Set the water level selector at maximum fill and insert the appropriate test load, if applicable. Activate the cycle of the clothes washer and also any suds-saver switch. Set the wash/rinse temperature selector to the temperature combination setting that is locked out in the normal cycle and repeat sections 3.2.3.1.2 through 3.2.3.1.5.

3.2.4.2 Repeat section 3.2.4.1 under the same temperature combination setting for all other untested non-normal cycles on the machine that have the wash/rinse temperature combination selection that is locked out.

3.2.4.3 Total the measured hot water consumption of the wash, deep rinse, and spray rinse of each non-normal cycle tested in sections 3.2.4.1 through 3.2.4.2 and compare the total for each cycle. The cycle that has the highest hot water consumption shall be the most energy intensive cycle for that particular wash/rinse temperature combination setting.

3.2.4.4 Set the water level selector at minimum fill and insert the appropriate test load, if applicable. Activate the most energy intensive cycle, as determined in section 3.2.4.3, of the clothes washer and also any suds-saver switch. Repeat tests as described in section 3.2.4.1.

3.3 *Remaining Moisture Content (RMC).*

3.3.1 The wash temperature shall be the same as the rinse temperature for all testing. Cold rinse is the coldest rinse temperature available on the machine. Warm rinse is the hottest rinse temperature available on the machine.

3.3.2 Determine the test load as shown in the following table:

Container volume		Test load	
cu. ft. ≥ <	liter ≥ <	lb	kg
0–0.80	0–22.7	3.00	1.36
0.80–0.90	22.7–25.5	3.50	1.59
0.90–1.00	25.5–28.3	3.90	1.77
1.00–1.10	28.3–31.1	4.30	1.95
1.10–1.20	31.1–34.0	4.70	2.13
1.20–1.30	34.0–36.8	5.10	2.31
1.30–1.40	36.8–39.6	5.50	2.49
1.40–1.50	39.6–42.5	5.90	2.68
1.50–1.60	42.5–45.3	6.40	2.90
1.60–1.70	45.3–48.1	6.80	3.08
1.70–1.80	48.1–51.0	7.20	3.27
1.80–1.90	51.0–53.8	7.60	3.45
1.90–2.00	53.8–56.6	8.00	3.63
2.00–2.10	56.6–59.5	8.40	3.81
2.10–2.20	59.5–62.3	8.80	3.99
2.20–2.30	62.3–65.1	9.20	4.17
2.30–2.40	65.1–68.0	9.60	4.35
2.40–2.50	68.0–70.8	10.00	4.54
2.50–2.60	70.8–73.6	10.50	4.76
2.60–2.70	73.6–76.5	10.90	4.94
2.70–2.80	76.5–79.3	11.30	5.13
2.80–2.90	79.3–82.1	11.70	5.31
2.90–3.00	82.1–85.0	12.10	5.49
3.00–3.10	85.0–87.8	12.50	5.67
3.10–3.20	87.8–90.6	12.90	5.85
3.20–3.30	90.6–93.4	13.30	6.03
3.30–3.40	93.4–96.3	13.70	6.21
3.40–3.50	96.3–99.1	14.10	6.40
3.50–3.60	99.1–101.9	14.60	6.62
3.60–3.70	101.9–104.8	15.00	6.80
3.70–3.80	104.8–107.6	15.40	6.99

NOTES: (1) All test load weights are bone dry weights.
(2) Allowable tolerance on the test load weights are ±0.10 lbs (0.05 kg).

3.3.3 For clothes washers with cold rinse only.

3.3.3.1 Record the actual bone dry weight of the test load (WI), then place the test load in the clothes washer.

3.3.3.2 Set water level selector to maximum fill.

3.3.3.3 Run the normal cycle.

3.3.3.4 Record the weight of the test load immediately after completion of the normal cycle (WC).

3.3.3.5 Calculate the remaining moisture content of the test load, RMC, expressed as a percentage and defined as:

$$RMC=[(WC-WI)/WI]\times100\%$$

3.3.4 For clothes washers with cold and warm rinse options.

3.3.4.1 Complete steps 3.3.3.1 through 3.3.3.4 for the cold rinse. Calculate the remaining moisture content of the test load for cold rinse, RMC_{COLD}, expressed as a percentage and defined as:

$$RMC_{COLD}=[(WC-WI)/WI]\times100\%$$

3.3.4.2 Complete steps 3.3.3.1 through 3.3.3.4 for the warm rinse. Calculate the remaining moisture content of the test load for warm rinse, RMC_{WARM}, expressed as a percentage and defined as:

$$RMC_{WARM}=[(WC-WI)/WI]\times100\%$$

3.3.4.3 Calculate the remaining moisture content of the test load, RMC, expressed as a percentage and defined as:

$$RMC=0.73\times RMC_{COLD}+0.27\times RMC_{WARM}$$

3.3.5 Clothes washers which have options that result in different RMC values, such as multiple selection of spin speeds or spin times that are available in the normal cycle, shall be tested at the maximum and minimum settings of the available options, excluding any "no spin" (zero spin speed) settings, in accordance with requirements in 3.3.3 or 3.3.4. The calculated $RMC_{max\ extraction}$ and $RMC_{min\ extraction}$ at the maximum and minimum settings, respectively, shall be combined as follows and the final RMC to be used in section 4.2 shall be:

$RMC=0.75\times RMC_{max\ extraction}+0.25\times RMC_{min\ extraction}$

3.4 *Data recording*. Record for each test cycle in sections 3.2.1 through 3.3.5.

3.4.1 For non-water-heating clothes washers, record the kilowatt-hours of electrical energy, M_E, consumed during the test to operate the clothes washer in section 3.2.3.1.2. For water-heating clothes washers record the kilowatt-hours of electrical energy, Eh_i consumed at maximum fill in sections 3.2.3.1.2 and 3.2.3.1.6, and Eh_j consumed at minimum fill in section 3.2.3.2.

3.4.2 Record the individual gallons (or liters) of hot and cold water consumption, Vh_i and Vc_i, measured at maximum fill level for each wash/rinse temperature combination setting tested in section 3.2.3, or in both 3.2.3 and 3.2.4, excluding any fresh make-up water required to complete the fill during a suds-return cycle.

3.4.3 Record the individual gallons (or liters) of hot and cold water consumption, Vh_j and Vc_j, measured at minimum fill level for each wash/rinse temperature combination setting tested in section 3.2.3, or in both 3.2.3 and 3.2.4, excluding any fresh make-up water required to complete the fill during a suds-return cycle.

3.4.4 Record the individual gallons (or liters) of hot and cold water, Sh_H and Sc_H, measured at maximum fill for the suds-return cycle.

3.4.5 Record the individual gallons (or liters) of hot and cold water, Sh_L and Sc_L, measured at minimum fill for the suds-return cycle.

3.4.6 Data recording requirements for RMC tests are listed in sections 3.3.3 through 3.3.5.

4. Calculation of Derived Results From Test Measurements

4.1 *Energy consumption.*

4.1.1 *Per-cycle temperature-weighted hot water consumption for maximum and minimum water fill levels*. Calculate for the cycle under test the per-cycle temperature weighted hot water consumption for the maximum water fill level, Vh_{max}, and for the minimum water fill level, Vh_{min}, expressed in gallons per cycle (or liters per cycle) and defined as:

$$Vh_{max} = X_1\sum_{i=1}^{n}\left[\left(Vh_i \times L\right)\times TUF_i\right] + X_2\left[TUF_W \times Sh_H\right]$$

$$Vh_{min} = X_1\sum_{j=1}^{n}\left[\left(Vh_j \times L\right)\times TUF_j\right] + X_2\left[TUF_W \times Sh_L\right]$$

where:

Vh_i=reported hot water consumption in gallons per cycle (or liters per cycle) at maximum fill for each wash/rinse temperature combination setting, as provided in section 3.4.2. If a clothes washer is equipped with two or more different wash/rinse temperature selections that have the same basic temperature combination selection label (for example, one of them has its water temperature controlled by thermostatically controlled valves and the other one does not), then the largest Vh_i shall be used for this calculation. If a clothes washer has lockout(s), there will be "Vh_i's" for wash/rinse temperature combination settings available in the normal cycle and "Vh_i's" for wash/rinse temperature combination settings in the most energy intensive cycle.

Vh_j=reported hot water consumption in gallons per cycle (or liters per cycle) at minimum fill for each wash/rinse temperature combination setting, as provided in section 3.4.3. If a clothes washer is equipped with two or more different wash/rinse temperature selections that have the same basic temperature combination selection label (for example, one of them has its water temperature controlled by thermostatically controlled valves and the other one does not), then the largest Vh_j shall be used for the calculation. If a clothes washer has lockouts, there will be "Vh_j's" for wash/rinse temperature combination settings available in the normal cycle and "Vh_j's" for wash/rinse temperature combination settings in the most energy intensive cycle.

L=lockout factor to be applied to the reported hot water consumption. For wash/rinse temperature combination settings that are not locked out in the normal cycle, L=1. For each wash/rinse temperature combination setting that is locked out in the normal cycle, L=0.32 in the normal cycle and L=0.68, in the most energy intensive cycle.

TUF_i=applicable temperature use factor in section 5 or 6.

TUF_j=applicable temperature use factor in section 5 or 6.

n=number of wash/rinse temperature combination settings available to the user for the clothes washer under test. For clothes washers that lockout temperature selections in the normal cycle, n=the number of wash/rinse temperature combination settings on the washers plus the number of wash/rinse temperature combination settings that lockout the temperature selections in the normal cycle.

TUF_w=temperature use factor for warm wash setting.

For clothes washers equipped with the suds-saver feature:

X_1=frequency of use without the suds-saver feature=0.86.

X_2=frequency of use with the suds-saver feature=0.14.

Sh_H=fresh make-up water measured during suds-return cycle at maximum water fill level.

Sh_L=fresh hot make-up water measured during suds-return cycle at minimum water fill level.

For clothes washers not equipped with the suds-saver feature:

X_1=1.0

X_2=0.0

4.1.2 *Total per-cycle hot water energy consumption for maximum and minimum water fill levels.* Calculate the total per-cycle hot water energy consumption for the maximum water fill level, E_{max} and for the minimum water fill level, E_{min}, expressed in kilowatt-hours per cycle and defined as:

$E_{max}=[Vh_{max} \times T \times K \times MF]$

$E_{min}=[Vh_{min} \times T \times K \times MF]$

where:

T=temperature rise=90 °F (50 °C).

K=water specific heat=0.00240 kWh/(gal– °F) [0.00114kWh/(L– °C)].

Vh_{max}=as defined in section 4.1.1.

Vh_{min}=as defined in section 4.1.1.

MF=multiplying factor to account for absence of test load=0.94 for top-loader vertical axis clothes washers that are sensor filled, 1.0 for all other clothes washers.

4.1.3 *Total weighted per-cycle hot water energy consumption expressed in kilowatt-hours.* Calculate the total weighted per cycle hot water energy consumption, E_T, expressed in kilowatt-hours per cycle and defined as:

$E_T=[E_{max} \times F_{max}]+[E_{min} \times F_{min}]$

where:

F_{max}=usage fill factor=0.72.

F_{min}=usage fill factor=0.28.

E_{max}=as defined in section 4.1.2.

E_{min}=as defined in section 4.1.2.

4.1.4 *Per-cycle water energy consumption using gas-heated or oil-heated water.* Calculate for the normal cycle the per-cycle energy consumption, E_{TG}, using gas-heated or oil-heated water, expressed in Btu per cycle (or megajoules per cycle) and defined as:

$$E_{TG} = E_T \times \frac{1}{e} \times \left[\frac{3412\ \text{Btu}}{\text{kWh}}\right] \text{ or } E_{TG} = E_T \times \frac{1}{e} \times \left[\frac{3.6\ \text{MJ}}{\text{kWh}}\right]$$

where:

e=nominal gas or oil water heater efficiency=0.75.

E_T=as defined in section 4.1.3.

4.1.5 *Per-cycle machine electrical energy consumption.*

4.1.5.1 *Non-water-heating clothes washers.* The electrical energy value recorded for the maximum fill in section 3.4.1 is the per-cycle machine electrical energy consumption, M_E, expressed in kilowatt-hours per cycle.

4.1.5.2 *Water-heating clothes washers.*

4.1.5.2.1 Calculate for the cycle under test the per-cycle temperature weighted electrical energy consumption for the maximum water fill level, Eh_{max}, and for the minimum water fill level, Eh_{min}, expressed in kilowatt-hours per cycle and defined as:

$$Eh_{max} = \sum_{i=1}^{n} \left[Eh_i \times TUF_i\right]$$

where:

Eh_i=reported electrical energy consumption in kilowatt-hours per cycle at maximum fill for each wash/cycle temperature combination setting, as provided in section 3.4.1.

TUF_i=applicable temperature use factor in section 5 or 6.

n=number of wash/rinse temperature combination settings available to the user for the clothes washer under test.

and

$$Eh_{min} = \sum_{j=1}^{n} \left[Eh_j \times TUF_j \right]$$

where:

Eh_j=reported electrical energy consumption in kilowatt-hours per cycle at minimum fill for each wash/rinse temperature combination setting, as provided in section 3.4.1.

TUF_j=applicable temperature use factor in section 5 or 6.

n=as defined above in this section.

4.1.5.2.2 *Weighted per-cycle machine electrical energy consumption.* Calculate the weighted per cycle machine energy consumption, M_E, expressed in kilowatt-hours per cycle and defined as:

$M_E=[Eh_{max}\times F_{max}]+[Eh_{min}\times F_{min}]$

where:

F_{max}=as defined in section 4.1.3.
F_{min}=as defined in section 4.1.3.
Eh_{max}=as defined in section 4.1.5.2.1.
Eh_{min}=as defined in section 4.1.5.2.1

4.1.6 *Total per-cycle energy consumption when electrically heated water is used.* Calculate for the normal cycle the total per-cycle energy consumption, E_{TE}, using electrically heated water, expressed in kilowatt-hours per cycle and defined as:

$E_{TE}=E_T+M_E$

where:

E_T=as defined in section 4.1.3.
M_E=as defined in section 4.1.5.1 or 4.1.5.2.2.

4.2 *Per-cycle energy consumption for removal of RMC.* Calculate the amount of energy per cycle required to remove RMC. Such amount is D_E, expressed in kilowatt-hours per cycle and defined as:

$D_E=(LAF)\times(\text{test load weight})\times(RMC-4\%)\times(DEF)\times(DUF)$

where:

LAF=load adjustment factor=0.52.

Test load weight=as shown in test load table in 3.3.2 expressed in lbs/cycle.

RMC=as defined in 3.3.3.5, 3.3.4.3, or 3.3.5.

DEF=nominal energy required for a clothes dryer to remove moisture from clothes=0.5 kWh/lb (1.1 kWh/kg).

DUF=dryer usage factor, percentage of washer loads dried in a clothes dryer=0.84.

4.3 *Water consumption.*

4.3.1 *Per-cycle temperature-weighted water consumption for maximum and minimum water fill levels.* To determine these amounts, calculate for the cycle under test the per-cycle temperature-weighted total water consumption for the maximum water fill level, Q_{max}, and for the minimum water fill level, Q_{min}, expressed in gallons per cycle (or liters per cycle) and defined as:

$$Q_{max} = X_1 \sum_{i=1}^{n} \left[\left(Vh_i + Vc_i \right) \times TUF_i \right] + X_2 \left[TUF_w \times \left(Sh_H + Sc_H \right) \right]$$

where:

Vh_i=hot water consumption in gallons per-cycle at maximum fill for each wash/rinse temperature combination setting, as provided in section 3.4.2.

Vc_i=total cold water consumption in gallons per-cycle at maximum fill for each wash/rinse temperature combination setting, cold wash/cold rinse cycle, as provided in section 3.4.2.

TUF_i=applicable temperature use factor in section 5 or 6.

n=number of wash/rinse temperature combination settings available to the user for the clothes washer under test.

TUF_w=temperature use factor for warm wash setting.

For clothes washers equipped with suds-saver feature:

X_1=frequency of use without suds-saver feature=0.86

X_2=frequency of use with suds-saver feature=0.14

Sh_H=fresh hot water make-up measured during suds-return cycle at maximum water fill level.

Sc_H=fresh cold water make-up measured during suds-return cycle at maximum water fill level.

For clothes washers not equipped with suds-saver feature:

X_1=1.0
X_2=0.0

and

$$Q_{min} = X_1 \sum_{j=1}^{n} \left[\left(Vh_j + Vc_j \right) \times TUF_j \right] + X_2 \left[TUF_w \times \left(Sh_L + Sc_L \right) \right]$$

where:

Vh_j=hot water consumption in gallons per cycle (or liters per cycle) at minimum fill for each wash/rinse temperature combination setting, as provided in section 3.4.3.

Vc_j=cold water consumption in gallons per cycle (or liters per cycle) at minimum fill for each wash/rinse temperature combination setting, cold wash/cold rinse cycle, as provided in section 3.4.3.

TUF_j=applicable temperature use factor in section 5 or 6.

Sh_L=fresh hot make-up water measured during suds-return cycle at minimum water fill level.

Sc_L=fresh cold make-up water measured during suds-return cycle at minimum water fill level.

n=as defined above in this section.

TUF_w=as defined above in this section.

X_1=as defined above in this section.

X_2=as defined above in this section.

4.3.2 *Total weighted per-cycle water consumption*. To determine this amount, calculate the total weighted per cycle water consumption, Q_T, expressed in gallons per cycle (or liters per cycle) and defined as:

$Q_T=[Q_{max} \times F_{max}]+[Q_{min} \times F_{min}]$

where:

F_{max}=as defined in section 4.1.3.

F_{min}=as defined in section 4.1.3.

Q_{max}=as defined in section 4.3.1.

Q_{min}=as defined in section 4.3.1.

4.3.3 *Water consumption factor*. The following calculates the water consumption factor, WCF, expressed in gallon per cycle per cubic foot (or liter per cycle per liter):

$WCF=Q_T/C$

where:

C=as defined in section 3.1.5.

Q_T=as defined in section 4.3.2.

4.4 *Modified energy factor*. The following calculates the modified energy factor, MEF, expressed in cubic feet per kilowatt-hours per cycle (or liters per kilowatt-hours per cycle):

$$MEF = \frac{C}{\left(M_E + E_T + D_E \right)}$$

where:

C=as defined in section 3.1.5.

M_E=as defined in section 4.1.5.1 or 4.1.5.2.2.

E_T=as defined in section 4.1.3.

D_E=as defined in section 4.2.

4.5 *Energy factor*. Calculate the energy factor, EF, expressed in cubic feet per kilowatt-hours per cycle (or liters per kilowatt-hours per cycle), as:

$$EF = \frac{C}{\left(M_E + E_T \right)}$$

where:

C=as defined in section 3.1.5.

M_E=as defined in section 4.1.5.1 or 4.1.5.2.2.

E_T=as defined in section 4.1.3.

5. Applicable Temperature Use Factors for Determining Hot Water Usage for Various Wash/Rinse Temperature Selections for All Automatic Clothes Washers

5.1 *Clothes washers with discrete temperature selections*.

5.1.1 *Five-temperature selection (n=5)*.

Wash/rinse temperature setting	Temperature Use Factor (TUF)
Hot/Warm	0.18
Hot/Cold	.12
Warm/Warm	.30
Warm/Cold	.25
Cold/Cold	.15

5.1.2 *Four-temperature selection (n=4)*.

Wash/rinse temperature setting	Temperature Use Factor (TUF)
Alternate I:	
Hot/Warm	0.18
Hot/Cold	.12
Warm/Cold	.55
Cold/Cold	.15
Alternate II:	
Hot/Warm	0.18
Hot/Cold	.12
Warm/Warm	.30
Warm/Cold	.40
Alternate III:	
Hot/Cold	0.12
Warm/Warm	.18
Warm/Cold	.55
Cold/Cold	.15

5.1.3 *Three-temperature selection (n=3)*.

Wash/rinse temperature setting	Temperature Use Factor (TUF)
Alternate I:	
Hot/Warm	0.30
Warm/Cold	.55
Cold/Cold	.15
Alternate II:	
Hot/Cold	0.30

Wash/rinse temperature setting	Temperature Use Factor (TUF)
Warm/Cold	.55
Cold/Cold	.15
Alternate III:	
Hot/Cold	0.30
Warm/Warm	.55
Cold/Cold	.15

5.1.4 *Two-temperature selection (n=2).*

Wash/rinse temperature setting	Temperature Use Factor (TUF)
Any heated water/Cold	0.85
Cold/Cold	.15

5.1.5 *One-temperature selection (n=1).*

Wash/rinse temperature setting	Temperature Use Factor (TUF)
Any	1.00

5.2 *Clothes washers with infinite temperature selections.*

Wash/rinse temperature setting	Temperature Use Factor (TUF)	
	≤ 140 °F (60 °C) (n=3)	> 140 °F (60 °C) (n=4)
Extra-hot	....	0.05
Hot	0.30	0.25
Warm	0.55	0.55
Cold	0.15	0.15

6. Applicable Temperature Use Factors for Determining Hot Water Usage for Various Wash/Rinse Temperature Settings for All Semi-Automatic, Non-Water-Heating, Clothes Washers

6.1 *Six-temperature settings (n=6).*

Wash/rinse temperature setting	Temperature Use Factor (TUF)
Hot/Hot	0.15
Hot/Warm	.09
Hot/Cold	.06
Warm/Warm	.42
Warm/Cold	.13
Cold/Cold	.15

7. Waivers and Field Testing

7.1 *Waivers and Field Testing for Non-conventional Clothes Washers.* Manufacturers of non-conventional clothes washers, such as clothes washers with adaptive control systems, must submit a petition for waiver pursuant to 10 CFR 430.27 to establish an acceptable test procedure for that clothes washer. For these and other clothes washers that have controls or systems such that the DOE test procedures yield results that are so unrepresentative of the clothes washer's true energy consumption characteristics as to provide materially inaccurate comparative data, field testing may be appropriate for establishing an acceptable test procedure. The following are guidelines for field testing which may be used by manufacturers in support of petitions for waiver. These guidelines are not mandatory and the Department may determine that they do not apply to a particular model. Depending upon a manufacturer's approach for conducting field testing, additional data may be required. Manufacturers are encouraged to communicate with the Department prior to the commencement of field tests which may be used to support a petition for waiver. Section 7.3 provides an example of field testing for a clothes washer with an adaptive water fill control system. Other features, such as the use of various spin speed selections, could be the subject of field tests.

7.2 *Non-conventional Wash System Energy Consumption Test.* The field test may consist of a minimum of 10 of the nonconventional clothes washers (''test clothes washers'') and 10 clothes washers already being distributed in commerce (''base clothes washers''). The tests should include a minimum of 50 normal test cycles per clothes washer. The test clothes washers and base clothes washers should be identical in construction except for the controls or systems being tested. Equal numbers of both the test clothes washer and the base clothes washer should be tested simultaneously in comparable settings to minimize seasonal and/or consumer laundering conditions and/or variations. The clothes washers should be monitored in such a way as to accurately record the total energy consumption per cycle. At a minimum, the following should be measured and recorded throughout the test period for each clothes washer: Hot water usage in gallons (or liters), electrical energy usage in kilowatt-hours, and the cycles of usage. The field test results would be used to determine the best method to correlate the rating of the test clothes washer to the rating of the base clothes washer. If the base clothes washer is rated at A kWh per year, but field tests at B kWh per year, and the test clothes washer field tests at D kWh per year, the test unit would be rated as follows:

$$A \times (D/B) = G \text{ kWh per year}$$

7.3 *Adaptive water fill control system field test.* Section 3.2.2.1 defines the test method for measuring energy consumption for clothes washers which incorporate control systems having both adaptive and alternate manual selections. Energy consumption calculated by the method defined in section 3.2.2.1 assumes the adaptive cycle will be used 50 percent of the time. This section can be used to develop field test data in support of a petition for waiver when it is believed that the adaptive cycle will be used more than 50 percent of the time. The field test sample size should be a minimum of 10 test clothes washers. The test clothes washers should be totally representative of the design, construction, and control system that will be placed in commerce. The duration of field testing in the user's house should be a minimum of 50 normal test cycles, for each unit. No special instructions as to cycle selection or product usage should be given to the field test participants, other than inclusion of the product literature pack which should be shipped with all units, and instructions regarding filling out data collection forms, use of data collection equipment, or basic procedural methods. Prior to the test clothes washers being installed in the field test locations, baseline data should be developed for all field test units by conducting laboratory tests as defined by section 1 through section 6 of these test procedures to determine the energy consumption values. The following data should be measured and recorded for each wash load during the test period: wash cycle selected, the mode of the clothes washer (adaptive or manual), clothes load dry weight (measured after the clothes washer and clothes dryer cycles are completed) in pounds, and type of articles in the clothes load (i.e., cottons, linens, permanent press, etc.). The wash loads used in calculating the in-home percentage split between adaptive and manual cycle usage should be only those wash loads which conform to the definition of the normal test cycle.

Calculate:

T=The total number of normal test cycles run during the field test

T_a=The total number of adaptive control normal test cycles

T_m=The total number of manual control normal test cycles

The percentage weighting factors:

$P_a=(T_a/T) \times 100$ (the percentage weighting for adaptive control selection)

$P_m=(T_m/T) \times 100$ (the percentage weighting for manual control selection)

Energy consumption values, E_T, M_E, and D_E (if desired) calculated in section 4 for the manual and adaptive modes, should be combined using P_a and P_m as the weighting factors.

8. Sunset

The provisions of this appendix J expire on December 31, 2003.

[62 FR 45501, Aug. 27, 1997, as amended at 66 FR 3330, Jan. 12, 2001; 66 FR 8745, Feb. 2, 2001]

APPENDIX J1 TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF AUTOMATIC AND SEMI-AUTOMATIC CLOTHES WASHERS

The provisions of this appendix J1 shall apply to products manufactured beginning January 1, 2004.

1. Definitions and Symbols

1.1 *Adaptive control system* means a clothes washer control system, other than an adaptive water fill control system, which is capable of automatically adjusting washer operation or washing conditions based on characteristics of the clothes load placed in the clothes container, without allowing or requiring consumer intervention or actions. The automatic adjustments may, for example, include automatic selection, modification, or control of any of the following: wash water temperature, agitation or tumble cycle time, number of rinse cycles, and spin speed. The characteristics of the clothes load, which could trigger such adjustments, could, for example, consist of or be indicated by the presence of either soil, soap, suds, or any other additive laundering substitute or complementary product.

NOTE: Appendix J1 does not provide a means for determining the energy consumption of a clothes washer with an adaptive control system. Therefore, pursuant to 10 CFR 430.27, a waiver must be obtained to establish an acceptable test procedure for each such clothes washer.

1.2 *Adaptive water fill control system* means a clothes washer water fill control system which is capable of automatically adjusting the water fill level based on the size or weight of the clothes load placed in the clothes container, without allowing or requiring consumer intervention or actions.

1.3 *Bone-dry* means a condition of a load of test cloth which has been dried in a dryer at maximum temperature for a minimum of 10 minutes, removed and weighed before cool down, and then dried again for 10 minute periods until the final weight change of the load is 1 percent or less.

1.4 *Clothes container* means the compartment within the clothes washer that holds the clothes during the operation of the machine.

1.5 *Compact* means a clothes washer which has a clothes container capacity of less than 1.6 ft^3 (45 L).

1.6 *Deep rinse cycle* means a rinse cycle in which the clothes container is filled with water to a selected level and the clothes load is rinsed by agitating it or tumbling it through the water.

1.7 *Energy test cycle* for a basic model means (A) the cycle recommended by the manufacturer for washing cotton or linen clothes, and includes all wash/rinse temperature selections and water levels offered in that cycle, and (B) for each other wash/rinse temperature selection or water level available on that basic model, the portion(s) of other cycle(s) with that temperature selection or water level that, when tested pursuant to these test procedures, will contribute to an accurate representation of the energy consumption of the basic model as used by consumers. Any cycle under (A) or (B) shall include the agitation/tumble operation, spin speed(s), wash times, and rinse times applicable to that cycle, including water heating time for water heating clothes washers.

1.8 *Load use factor* means the percentage of the total number of wash loads that a user would wash a particular size (weight) load.

1.9 *Manual control system* means a clothes washer control system which requires that the consumer make the choices that determine washer operation or washing conditions, such as, for example, wash/rinse temperature selections, and wash time before starting the cycle.

1.10 *Manual water fill control system* means a clothes washer water fill control system which requires the consumer to determine or select the water fill level.

1.11 *Modified energy factor* means the quotient of the cubic foot (or liter) capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water energy consumption, and the energy required for removal of the remaining moisture in the wash load.

1.12 *Non-water-heating clothes washer* means a clothes washer which does not have an internal water heating device to generate hot water.

1.13 *Spray rinse cycle* means a rinse cycle in which water is sprayed onto the clothes for a period of time without maintaining any specific water level in the clothes container.

1.14 *Standard* means a clothes washer which has a clothes container capacity of 1.6 ft^3 (45 L) or greater.

1.15 *Temperature use factor* means, for a particular wash/rinse temperature setting, the percentage of the total number of wash loads that an average user would wash with that setting.

1.16 *Thermostatically controlled water valves* means clothes washer controls that have the ability to sense and adjust the hot and cold supply water.

1.17 *Uniformly distributed warm wash temperature selection(s)* means (A) multiple warm wash selections for which the warm wash water temperatures have a linear relationship with all discrete warm wash selections when the water temperatures are plotted against equally spaced consecutive warm wash selections between the hottest warm wash and the coldest warm wash. If the warm wash has infinite selections, the warm wash water temperature has a linear relationship with the distance on the selection device (e.g. dial angle or slide movement) between the hottest warm wash and the coldest warm wash. The criteria for a linear relationship as specified above is that the difference between the actual water temperature at any warm wash selection and the point where that temperature is depicted on the temperature/selection line formed by connecting the warmest and the coldest warm selections is less than ±5 percent. In all cases, the mean water temperature of the warmest and the coldest warm selections must coincide with the mean of the ''hot wash'' (maximum wash temperature ≤135 °F (57.2 °C)) and ''cold wash'' (minimum wash temperature) water temperatures within ±3.8 °F (±2.1 °C); or (B) on a clothes washer with only one warm wash temperature selection, a warm wash temperature selection with a water temperature that coincides with the mean of the ''hot wash'' (maximum wash temperature ≤135 °F (57.2 °C)) and ''cold wash'' (minimum wash temperature) water temperatures within ±3.8 °F (±2.1 °C).

1.18 *Warm wash* means all wash temperature selections that are below the hottest hot, less than 135 °F (57.2 °C), and above the coldest cold temperature selection.

1.19 *Water consumption factor* means the quotient of the total weighted per-cycle water consumption divided by the cubic foot (or liter) capacity of the clothes washer.

1.20 *Water-heating clothes washer* means a clothes washer where some or all of the hot water for clothes washing is generated by a water heating device internal to the clothes washer.

1.21 *Symbol usage*. The following identity relationships are provided to help clarify the symbology used throughout this procedure.

E—Electrical Energy Consumption
H—Hot Water Consumption
C—Cold Water Consumption
R—Hot Water Consumed by Warm Rinse
ER—Electrical Energy Consumed by Warm Rinse
TUF—Temperature Use Factor
HE—Hot Water Energy Consumption
F—Load Usage Factor
Q—Total Water Consumption
ME—Machine Electrical Energy Consumption
RMC—Remaining Moisture Content
WI—Initial Weight of Dry Test Load
WC—Weight of Test Load After Extraction
m—Extra Hot Wash (maximum wash temp. >135 °F (57.2 °C.))
h—Hot Wash (maximum wash temp. ≤135 °F (57.2 °C.))
w—Warm Wash
c—Cold Wash (minimum wash temp.)
r—Warm Rinse (hottest rinse temp.)
x or max—Maximum Test Load

a or avg—Average Test Load
n or min—Minimum Test Load

The following examples are provided to show how the above symbols can be used to define variables:

Em_x=''Electrical Energy Consumption'' for an ''Extra Hot Wash'' and ''Maximum Test Load''
R_a=''Hot Water Consumed by Warm Rinse'' for the ''Average Test Load''
TUF_m=''Temperature Use Factor'' for an ''Extra Hot Wash''
HE_{min}=''Hot Water Energy Consumption'' for the ''Minimum Test Load''

1.22 *Cold rinse* means the coldest rinse temperature available on the machine (and should be the same rinse temperature selection tested in 3.7 of this appendix).

1.23 *Warm rinse* means the hottest rinse temperature available on the machine (and should be the same rinse temperature selection tested in 3.7 of this appendix).

2. Testing Conditions

2.1 *Installation*. Install the clothes washer in accordance with manufacturer's instructions.

2.2 *Electrical energy supply*. Maintain the electrical supply at the clothes washer terminal block within 2 percent of 120, 120/240, or 120/208Y volts as applicable to the particular terminal block wiring system and within 2 percent of the nameplate frequency as specified by the manufacturer. If the clothes washer has a dual voltage conversion capability, conduct test at the highest voltage specified by the manufacturer.

2.3 *Supply Water*.

2.3.1 *Clothes washers in which electrical energy consumption or water energy consumption are affected by the inlet water temperature. (For example, water heating clothes washers or clothes washers with thermostatically controlled water valves.)*. The temperature of the hot water supply at the water inlets shall not exceed 135 °F (57.2 °C) and the cold water supply at the water inlets shall not exceed 60 °F (15.6 °C). A water meter shall be installed in both the hot and cold water lines to measure water consumption.

2.3.2 *Clothes washers in which electrical energy consumption and water energy consumption are not affected by the inlet water temperature*. The temperature of the hot water supply shall be maintained at 135 °F±5 °F (57.2 °C±2.8 °C) and the cold water supply shall be maintained at 60 °F±5 °F (15.6 °C±2.8 °C). A water meter shall be installed in both the hot and cold water lines to measure water consumption.

2.4 *Water pressure*. The static water pressure at the hot and cold water inlet connection of the clothes washer shall be maintained at 35 pounds per square inch gauge (psig) ±2.5 psig (241.3 kPa±17.2 kPa) during the test. The static water pressure for a single water inlet connection shall be maintained at 35 psig±2.5 psig (241.3 kPa±17.2 kPa) during the test. A water pressure gauge shall be installed in both the hot and cold water lines to measure water pressure.

2.5 *Instrumentation*. Perform all test measurements using the following instruments, as appropriate:

2.5.1 *Weighing scales*.

2.5.1.1 *Weighing scale for test cloth*. The scale shall have a resolution of no larger than 0.2 oz (5.7 g) and a maximum error no greater than 0.3 percent of the measured value.

2.5.1.2 *Weighing scale for clothes container capacity measurements*. The scale should have a resolution no larger than 0.50 lbs (0.23 kg) and a maximum error no greater than 0.5 percent of the measured value.

2.5.2 *Watt-hour meter*. The watt-hour meter shall have a resolution no larger than 1 Wh (3.6 kJ) and a maximum error no greater than 2 percent of the measured value for any demand greater than 50 Wh (180.0 kJ).

2.5.3 *Temperature measuring device*. The device shall have an error no greater than ±1 °F (±0.6 °C) over the range being measured.

2.5.4 *Water meter*. The water meter shall have a resolution no larger than 0.1 gallons (0.4 liters) and a maximum error no greater than 2 percent for the water flow rates being measured.

2.5.5 *Water pressure gauge*. The water pressure gauge shall have a resolution of 1 pound per square inch gauge (psig) (6.9 kPa) and shall have an error no greater than 5 percent of any measured value.

2.6 *Test cloths*.

2.6.1 *Energy Test Cloth*. The energy test cloth shall be made from energy test cloth material, as specified in 2.6.4, that is 24 inches by 36 inches (61.0 cm by 91.4 cm) and has been hemmed to 22 inches by 34 inches (55.9 cm by 86.4 cm) before washing. The energy test cloth shall be clean and shall not be used for more than 60 test runs (after preconditioning as specified in 2.6.3 of this appendix). All energy test cloth must be permanently marked identifying the lot number of the material. Mixed lots of material shall not be used for testing the clothes washers.

2.6.1.1 The energy test cloth shall not be used for more than 25 test runs and shall be clean and consist of the following:

(A) Pure finished bleached cloth, made with a momie or granite weave, which is 50 percent cotton and 50 percent polyester and weighs 5.75 ounces per square yard (195.0 g/m^2) and has 65 ends on the warp and 57 picks on the fill; and

(B) Cloth material that is 24 inches by 36 inches (61.0 cm by 91.4 cm) and has been hemmed to 22 inches by 34 inches (55.9 cm by 86.4 cm) before washing. The maximum shrinkage after five washes shall not be more than four percent on the length and width.

2.6.1.2 The new test cloths, including energy test cloths and energy stuffer cloths, shall be pre-conditioned in a clothes washer in the following manner:

2.6.1.2.1 Wash the test cloth using a commercially available clothes washing detergent that is suitable for 135 °F (57.2 °C) wash water as recommended by the manufacturer, with the washer set on maximum water level. Place detergent in washer and then place the new load to be conditioned in the washer. Wash the load for ten minutes in soft water (17ppm or less). Wash water is to be hot, and controlled at 135 °F±5 °F (57.2 °C ±2.8 °C). Rinse water temperature is to be cold, and controlled at 60 °F ±5 °F (15.6 °C ±2.8 °C). Rinse the load through a second rinse using the same water temperature (if an optional second rinse is available on the clothes washer, use it).

2.6.1.2.2 Dry the load.

2.6.1.2.3 A final cycle is to be hot water wash with no detergent followed by two cold water rinses.

2.6.1.2.4 Dry the load.

2.6.2 *Energy Stuffer Cloth.* The energy stuffer cloth shall be made from energy test cloth material, as specified in 2.6.4, and shall consist of pieces of material that are 12 inches by 12 inches (30.5 cm by 30.5 cm) and have been hemmed to 10 inches by 10 inches (25.4 cm by 25.4 cm) before washing. The energy stuffer cloth shall be clean and shall not be used for more than 60 test runs (after preconditioning as specified in 2.6.3 of this appendix). All energy stuffer cloth must be permanently marked identifying the lot number of the material. Mixed lots of material shall not be used for testing the clothes washers.

2.6.3 *Preconditioning of Test Cloths.* The new test cloths, including energy test cloths and energy stuffer cloths, shall be pre-conditioned in a clothes washer in the following manner:

2.6.3.1 Perform 5 complete normal wash-rinse-spin cycles, the first two with AHAM Standard detergent 2A and the last three without detergent. Place the test cloth in a clothes washer set at the maximum water level. Wash the load for ten minutes in soft water (17 ppm hardness or less) using 6.0 grams per gallon of water of AHAM Standard detergent 2A. The wash temperature is to be controlled to 135 °F ±5 °F (57.2 °C ±2.8 °C) and the rinse temperature is to be controlled to 60 °F ±5 °F (15.6 °C ±2.8 °C). Repeat the cycle with detergent and then repeat the cycle three additional times without detergent, bone drying the load between cycles (total of five wash and rinse cycles).

2.6.4 *Energy test cloth material.* The energy test cloths and energy stuffer cloths shall be made from fabric meeting the following specifications. The material should come from a roll of material with a width of approximately 63 inches and approximately 500 yards per roll, however, other sizes maybe used if they fall within the specifications.

2.6.4.1 *Nominal fabric type.* Pure finished bleached cloth, made with a momie or granite weave, which is nominally 50 percent cotton and 50 percent polyester.

2.6.4.2 The fabric weight shall be 5.60 ounces per square yard (190.0 g/m^2), ±5 percent.

2.6.4.3 The thread count shall be 61 × 54 per inch (warp × fill), ±2 percent.

2.6.4.4 The warp yarn and filling yarn shall each have fiber content of 50 percent ±4 percent cotton, with the balance being polyester, and be open end spun, 15/1 ±5 percent cotton count blended yarn.

2.6.4.5 Water repellent finishes, such as fluoropolymer stain resistant finishes shall not be applied to the test cloth. The absence of such finishes shall be verified by:

2.6.4.5.1 American Association of Textile Chemists and Colorists (AATCC) Test Method 118—1997, *Oil Repellency: Hydrocarbon Resistance Test* (reaffirmed 1997), of each new lot of test cloth (when purchased from the mill) to confirm the absence of Scotchguard™ or other water repellent finish (required scores of ''D'' across the board).

2.6.4.5.2 American Association of Textile Chemists and Colorists (AATCC) Test Method 79–2000, *Absorbency of Bleached Textiles* (reaffirmed 2000), of each new lot of test cloth (when purchased from the mill) to confirm the absence of Scotchguard™ or other water repellent finish (time to absorb one drop should be on the order of 1 second).

2.6.4.5.3 The standards listed in 2.6.4.5.1 and 2.6.4.5.2 of this appendix which are not otherwise set forth in this part 430 are incorporated by reference. The material listed in this paragraph has been approved for incorporation by reference by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Any subsequent amendment to a standard by the standard-setting organization will not affect the DOE test procedures unless and until amended by DOE. Material is incorporated as it exists on the date of the approval and notice of any change in the material will be published in the FEDERAL REGISTER. The standards incorporated by reference are the American Association of Textile Chemists and Colorists Test Method 118–1997, *Oil Repellency: Hydrocarbon Resistance Test* (reaffirmed 1997) and Test Method 79–2000, *Absorbency of Bleached Textiles* (reaffirmed 2000).

(a) The above standards incorporated by reference are available for inspection at:

(i) National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.*

(ii) U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Hearings and Dockets, ‘‘Energy Conservation Program for Consumer Products: Clothes Washer Energy Conservation Standards,’’ Docket No. EE—RM–94–403, Forrestal Building, 1000 Independence Avenue, SW, Washington, DC.

(b) Copies of the above standards incorporated by reference can be obtained from the American Association of Textile Chemists and Colorists, P.O. Box 1215, Research Triangle Park, NC 27709, telephone (919) 549–8141, telefax (919) 549–8933, or electronic mail: *orders@aatcc.org*.

2.6.4.6 The moisture absorption and retention shall be evaluated for each new lot of test cloth by the Standard Extractor Remaining Moisture Content (RMC) Test specified in 2.6.5 of this appendix.

2.6.4.6.1 Repeat the Standard Extractor RMC Test in 2.6.5 of this appendix three times.

2.6.4.6.2 An RMC correction curve shall be calculated as specified in 2.6.6 of this appendix.

2.6.5 *Standard Extractor RMC Test Procedure*. The following procedure is used to evaluate the moisture absorption and retention characteristics of a lot of test cloth by measuring the RMC in a standard extractor at a specified set of conditions. Table 2.6.5 of this appendix is the matrix of test conditions. The 500g requirement will only be used if a clothes washer design can achieve spin speeds in the 500g range. When this matrix is repeated 3 times, a total of 48 extractor RMC test runs are required. For the purpose of the extractor RMC test, the test cloths may be used for up to 60 test runs (after preconditioning as specified in 2.6.3 of this appendix).

TABLE 2.6.5—MATRIX OF EXTRACTOR RMC TEST CONDITIONS

“g Force”	Warm soak		Cold soak	
	15 min. spin	4 min. spin	15 min. spin	4 min. spin
100				
200				
350				
500				

2.6.5.1 The standard extractor RMC tests shall be run in a Bock Model 215 extractor (having a basket diameter of 19.5 inches, length of 12 inches, and volume of 2.1 ft^3), with a variable speed drive (Bock Engineered Products, P.O. Box 5127, Toledo, OH 43611) or an equivalent extractor with same basket design (*i.e.* diameter, length, volume, and hole configuration) and variable speed drive.

2.6.5.2 *Test Load*. Test cloths shall be preconditioned in accordance with 2.6.3 of this appendix. The load size shall be 8.4 lbs., consistent with 3.8.1 of this appendix.

2.6.5.3 *Procedure*.

2.6.5.3.1 Record the ‘‘bone-dry’’ weight of the test load (WI).

2.6.5.3.2 Soak the test load for 20 minutes in 10 gallons of soft (<17 ppm) water. The entire test load shall be submerged. The water temperature shall be 100 °F ±5 °F.

2.6.5.3.3 Remove the test load and allow water to gravity drain off of the test cloths. Then manually place the test cloths in the basket of the extractor, distributing them evenly by eye. Spin the load at a fixed speed corresponding to the intended centripetal acceleration level (measured in units of the acceleration of gravity, g) ±1 g for the intended time period ±5 seconds.

2.6.5.3.4 Record the weight of the test load immediately after the completion of the extractor spin cycle (WC).

2.6.5.3.5 Calculate the RMC as (WC-WI)/WI.

2.6.5.3.6 The RMC of the test load shall be measured at three (3) g levels: 100g; 200g; and 350g, using two different spin times at each g level: 4 minutes; and 15 minutes. If a clothes washer design can achieve spin speeds in the 500g range then the RMC of the test load shall be measured at four (4) g levels: 100g; 200g; 350g; and 500g, using two different spin times at each g level: 4 minutes; and 15 minutes.

2.6.5.4 Repeat 2.6.5.3 of this appendix using soft (<17 ppm) water at 60 °F ±5 °F.

2.6.6 *Calculation of RMC correction curve*.

2.6.6.1 Average the values of 3 test runs and fill in table 2.6.5 of this appendix. Perform a linear least-squares fit to relate the standard RMC ($RMC_{standard}$) values (shown in table 2.6.6.1 of this appendix) to the values measured in 2.6.5 of this appendix:

(RMC_{cloth}): $RMC_{standard} \sim A * RMC_{cloth} + B$

Where A and B are coefficients of the linear least-squares fit.

TABLE 2.6.6.1—STANDARD RMC VALUES (RMC STANDARD)

“g Force”	RMC %			
	Warm soak		Cold soak	
	15 min. spin	4 min. spin	15 min. spin	4 min. spin
100	45.9	49.9	49.7	52.8
200	35.7	40.4	37.9	43.1
350	29.6	33.1	30.7	35.8
500	24.2	28.7	25.5	30.0

2.6.6.2. Perform an analysis of variance test using two factors, spin speed and lot, to check the interaction of speed and lot. Use the values from Table 2.6.5 and Table 2.6.6.1 in the calculation. The ‘‘P’’ value in the variance analysis shall be greater than or equal to 0.1. If the ‘‘P’’ value is less than 0.1 the test cloth is unacceptable. ‘‘P’’ is a theoretically based probability of interaction based on an analysis of variance.

2.6.7 *Application of RMC correction curve*.

2.6.7.1 Using the coefficients A and B calculated in 2.6.6.1 of this appendix:

$RMC_{corr} = A * RMC + B$

2.6.7.2 Substitute RMC_{corr} values in calculations in 3.8 of this appendix.

2.7 *Test Load Sizes.* Maximum, minimum, and, when required, average test load sizes shall be determined using Table 5.1 and the clothes container capacity as measured in 3.1.1 through 3.1.5. Test loads shall consist of energy test cloths, except that adjustments to the test loads to achieve proper weight can be made by the use of energy stuffer cloths with no more than 5 stuffer clothes per load.

2.8 *Use of Test Loads.* Table 2.8 defines the test load sizes and corresponding water fill settings which are to be used when measuring water and energy consumptions. Adaptive water fill control system and manual water fill control system are defined in section 1 of this appendix:

TABLE 2.8—TEST LOAD SIZES AND WATER FILL SETTINGS REQUIRED

Manual water fill control system		Adaptive water fill control system	
Test load size	Water fill setting	Test load size	Water fill setting
Max Min	Max Min	Max Avg Min	As determined by the Clothes Washer.

2.8.1 The test load sizes to be used to measure RMC are specified in section 3.8.1.

2.8.2 Test loads for energy and water consumption measurements shall be bone dry prior to the first cycle of the test, and dried to a maximum of 104 percent of bone dry weight for subsequent testing.

2.8.3 Load the energy test cloths by grasping them in the center, shaking them to hang loosely and then put them into the clothes container prior to activating the clothes washer.

2.9 *Pre-conditioning.*

2.9.1 *Nonwater-heating clothes washer.* If the clothes washer has not been filled with water in the preceding 96 hours, pre-condition it by running it through a cold rinse cycle and then draining it to ensure that the hose, pump, and sump are filled with water.

2.9.2 *Water-heating clothes washer.* If the clothes washer has not been filled with water in the preceding 96 hours, or if it has not been in the test room at the specified ambient conditions for 8 hours, pre-condition it by running it through a cold rinse cycle and then draining it to ensure that the hose, pump, and sump are filled with water.

2.10 *Wash time setting.* If one wash time is prescribed in the energy test cycle, that shall be the wash time setting; otherwise, the wash time setting shall be the higher of either the minimum, or 70 percent of the maximum wash time available in the energy test cycle.

2.11 *Test room temperature for water-heating clothes washers.* Maintain the test room ambient air temperature at 75 °F±5 °F (23.9 °C±2.8 °C).

3. Test Measurements

3.1 *Clothes container capacity.* Measure the entire volume which a dry clothes load could occupy within the clothes container during washer operation according to the following procedures:

3.1.1 Place the clothes washer in such a position that the uppermost edge of the clothes container opening is leveled horizontally, so that the container will hold the maximum amount of water.

3.1.2 Line the inside of the clothes container with 2 mil (0.051 mm) plastic sheet. All clothes washer components which occupy space within the clothes container and which are recommended for use with the energy test cycle shall be in place and shall be lined with 2 mil (0.051 mm) plastic sheet to prevent water from entering any void space.

3.1.3 Record the total weight of the machine before adding water.

3.1.4 Fill the clothes container manually with either 60 °F±5 °F (15.6 °C±2.8 °C) or 100 °F±10 °F (37.8 °C±5.5 °C) water to its uppermost edge. Measure and record the weight of water, W, in pounds.

3.1.5 The clothes container capacity is calculated as follows:

$C=W/d.$

where:

C=Capacity in cubic feet (liters).

W=Mass of water in pounds (kilograms).

d=Density of water (62.0 lbs/ft^3 for 100 °F (993 kg/m^3 for 37.8 °C) or 62.3 lbs/ft^3 for 60 °F (998 kg/m^3 for 15.6 °C)).

3.2 *Procedure for measuring water and energy consumption values on all automatic and semi-automatic washers.* All energy consumption tests shall be performed under the energy test cycle(s), unless otherwise specified. Table 3.2 defines the sections below which govern tests of particular clothes washers, based on the number of wash/rinse temperature selections available on the model, and also, in some instances, method of water heating. The procedures prescribed are applicable regardless of a clothes washer's washing capacity, loading port location, primary axis of rotation of the clothes container, and type of control system.

3.2.1 *Inlet water temperature and the wash/rinse temperature settings.*

3.2.1.1 For automatic clothes washers set the wash/rinse temperature selection control to obtain the wash water temperature desired (extra hot, hot, warm, or cold) and cold rinse, and open both the hot and cold water faucets.

3.2.1.2 For semi-automatic washers: (1) For hot water temperature, open the hot water faucet completely and close the cold water faucet; (2) for warm inlet water temperature, open both hot and cold water faucets completely; (3) for cold water temperature, close the hot water faucet and open the cold water faucet completely.

3.2.1.3 *Determination of warm wash water temperature(s) to decide whether a clothes washer has uniformly distributed warm wash temperature selections.* The wash water temperature, Tw, of each warm water wash selection shall be calculated or measured.

For non-water-heating clothes washers, calculate Tw as follows:

$$Tw(\,^{\circ}F)=((Hw\times 135\,^{\circ}F)+(Cw\times 60\,^{\circ}F))/(Hw+Cw)$$

or

$$Tw(\,^{\circ}C)=((Hw\times 57.2\,^{\circ}C)+(Cw\times 15.6\,^{\circ}C))/(Hw+Cw)$$

where:

Hw=Hot water consumption of a warm wash
Cw=Cold water consumption of a warm wash

For water-heating clothes washers, measure and record the temperature of each warm wash selection after fill.

3.2.2 Total water consumption during the energy test cycle shall be measured, including hot and cold water consumption during wash, deep rinse, and spray rinse.

3.2.3 *Clothes washers with adaptive water fill/manual water fill control systems*

3.2.3.1 *Clothes washers with adaptive water fill control system and alternate manual water fill control systems.* If a clothes washer with an adaptive water fill control system allows consumer selection of manual controls as an alternative, then both manual and adaptive modes shall be tested and, for each mode, the energy consumption (HE_T, ME_T, and D_E) and water consumption (Q_T), values shall be calculated as set forth in section 4. Then the average of the two values (one from each mode, adaptive and manual) for each variable shall be used in section 4 for the clothes washer.

3.2.3.2 *Clothes washers with adaptive water fill control system.*

3.2.3.2.1. Not user adjustable. The maximum, minimum, and average water levels as defined in the following sections shall be interpreted to mean that amount of water fill which is selected by the control system when the respective test loads are used, as defined in Table 2.8. The load usage factors which shall be used when calculating energy consumption values are defined in Table 4.1.3.

3.2.3.2.2 User adjustable. Four tests shall be conducted on clothes washers with user adjustable adaptive water fill controls which affect the relative wash water levels. The first test shall be conducted with the maximum test load and with the adaptive water fill control system set in the setting that will give the most energy intensive result. The second test shall be conducted with the minimum test load and with the adaptive water fill control system set in the setting that will give the least energy intensive result. The third test shall be conducted with the average test load and with the adaptive water fill control system set in the setting that will give the most energy intensive result for the given test load. The fourth test shall be conducted with the average test load and with the adaptive water fill control system set in the setting that will give the least energy intensive result for the given test load. The energy and water consumption for the average test load and water level, shall be the average of the third and fourth tests.

3.2.3.3 *Clothes washers with manual water fill control system.* In accordance with Table 2.8, the water fill selector shall be set to the maximum water level available on the clothes washer for the maximum test load size and set to the minimum water level for the minimum test load size. The load usage factors which shall be used when calculating energy consumption values are defined in Table 4.1.3.

TABLE 3.2—TEST SECTION REFERENCE

Max. Wash Temp. Available	≤135 °F (57.2 °C)		>135 °F (57.2 °C) [2]		
Number of Wash Temp. Selections	1	2	>2	3	>3
Test Sections Required to be Followed	....	....	....	3.3	3.3
	....	3.4	3.4	....	3.4
	....	....	3.5	3.5	3.5
	3.6	3.6	3.6	3.6	3.6
	[1] 3.7	[1] 3.7	[1] 3.7	[1] 3.7	[1] 3.7
	3.8	3.8	3.8	3.8	3.8

[1] Only applicable to machines with warm rinse in any cycle.
[2] This only applies to water hearting clothes washers on which the maximum wash temperature available exceeds 135 °F (57.2 °C)

3.3 *"Extra Hot Wash" (Max Wash Temp >135 °F (57.2 °C)) for water heating clothes washers only.* Water and electrical energy consumption shall be measured for each water fill level and/or test load size as specified in 3.3.1 through 3.3.3 for the hottest wash setting available.

3.3.1 *Maximum test load and water fill.* Hot water consumption (Hm_x), cold water consumption (Cm_x), and electrical energy consumption (Em_x) shall be measured for an extra hot wash/cold rinse energy test cycle, with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1.

3.3.2 *Minimum test load and water fill.* Hot water consumption (Hm_n), cold water consumption (Cm_n), and electrical energy consumption (Em_n) shall be measured for an extra hot wash/cold rinse energy test cycle, with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1.

3.3.3 *Average test load and water fill.* For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (Hm_a), cold water consumption (Cm_a), and electrical energy consumption (Em_a) for an extra hot wash/cold rinse energy test cycle, with an average test load size as determined per Table 5.1.

3.4 *''Hot Wash'' (Max Wash Temp≤135 °F (57.2 °C)).* Water and electrical energy consumption shall be measured for each water fill level or test load size as specified in 3.4.1 through 3.4.3 for a 135 °F (57.2 °C)) wash, if available, or for the hottest selection less than 135 °F (57.2 °C)).

3.4.1 *Maximum test load and water fill.* Hot water consumption (Hh_x), cold water consumption (Ch_x), and electrical energy consumption (Eh_x) shall be measured for a hot wash/cold rinse energy test cycle, with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1.

3.4.2 *Minimum test load and water fill.* Hot water consumption (Hh_n), cold water consumption (Ch_n), and electrical energy consumption (Eh_n) shall be measured for a hot wash/cold rinse energy test cycle, with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1.

3.4.3 *Average test load and water fill.* For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (Hh_a), cold water consumption (Ch_a), and electrical energy consumption (Eh_a) for a hot wash/cold rinse energy test cycle, with an average test load size as determined per Table 5.1.

3.5 ''*Warm Wash.*'' Water and electrical energy consumption shall be determined for each water fill level and/or test load size as specified in 3.5.1 through 3.5.2.3 for the applicable warm water wash temperature(s).

3.5.1 *Clothes washers with uniformly distributed warm wash temperature selection(s).* The reportable values to be used for the warm water wash setting shall be the arithmetic average of the measurements for the hot and cold wash selections. This is a calculation only, no testing is required.

3.5.2 *Clothes washers that lack uniformly distributed warm wash temperature selections.* For a clothes washer with fewer than four discrete warm wash selections, test all warm wash temperature selections. For a clothes washer that offers four or more warm wash selections, test at all discrete selections, or test at 25 percent, 50 percent, and 75 percent positions of the temperature selection device between the hottest hot (≤135 °F (57.2 °C)) wash and the coldest cold wash. If a selection is not available at the 25, 50 or 75 percent position, in place of each such unavailable selection use the next warmer setting. Each reportable value to be used for the warm water wash setting shall be the arithmetic average of all tests conducted pursuant to this section.

3.5.2.1 *Maximum test load and water fill.* Hot water consumption (Hw_x), cold water consumption (Cw_x), and electrical energy consumption (Ew_x) shall be measured with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1.

3.5.2.2 *Minimum test load and water fill.* Hot water consumption (Hw_n), cold water consumption (Cw_n), and electrical energy consumption (Ew_n) shall be measured with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1.

3.5.2.3 *Average test load and water fill.* For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (Hw_a), cold water consumption (Cw_a), and electrical energy consumption (Ew_a) with an average test load size as determined per Table 5.1.

3.6 *''Cold Wash'' (Minimum Wash Temperature Selection).* Water and electrical energy consumption shall be measured for each water fill level or test load size as specified in 3.6.1 through 3.6.3 for the coldest wash temperature selection available.

3.6.1 *Maximum test load and water fill.* Hot water consumption (Hc_x), cold water consumption (Cc_x), and electrical energy consumption (Ec_x) shall be measured for a cold wash/cold rinse energy test cycle, with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1.

3.6.2 *Minimum test load and water fill.* Hot water consumption (Hc_n), cold water consumption (Cc_n), and electrical energy consumption (Ec_n) shall be measured for a cold wash/cold rinse energy test cycle, with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1.

3.6.3 *Average test load and water fill.* For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (Hc_a), cold water consumption (Cc_a), and electrical energy consumption (Ec_a) for a cold wash/cold rinse energy test cycle, with an average test load size as determined per Table 5.1.

3.7 *Warm Rinse.* Tests in sections 3.7.1 and 3.7.2 shall be conducted with the hottest rinse temperature available. If multiple wash temperatures are available with the hottest rinse temperature, any ''warm wash'' temperature may be selected to conduct the tests.

3.7.1 For the rinse only, measure the amount of hot water consumed by the clothes washer including all deep and spray rinses, for the maximum (R_x), minimum (R_n), and, if required by section 3.5.2.3, average (R_a) test load sizes or water fill levels.

3.7.2 Measure the amount of electrical energy consumed by the clothes washer to heat the rinse water only, including all deep and spray rinses, for the maximum (ER_x), minimum (ER_n), and, if required by section 3.5.2.3, average (ER_a), test load sizes or water fill levels.

3.8 *Remaining Moisture Content:*

3.8.1 The wash temperature will be the same as the rinse temperature for all testing. Use the maximum test load as defined in Table 5.1 and section 3.1 for testing.

3.8.2 *For clothes washers with cold rinse only:*

3.8.2.1 Record the actual 'bone dry' weight of the test load (WI_{max}), then place the test load in the clothes washer.

3.8.2.2 Set water level selector to maximum fill.

3.8.2.3 Run the energy test cycle.

3.8.2.4 Record the weight of the test load immediately after completion of the energy test cycle (WC_{max}).

3.8.2.5 Calculate the remaining moisture content of the maximum test load, RMC_{MAX}, expressed as a percentage and defined as:

$$RMC_{max}=((WC_{max}-WI_{max})/WI_{max})\times 100\%$$

3.8.3 *For clothes washers with cold and warm rinse options:*

3.8.3.1 Complete steps 3.8.2.1 through 3.8.2.4 for cold rinse. Calculate the remaining moisture content of the maximum test load for cold rinse, RMC_{COLD}, expressed as a percentage and defined as:

$$RMC_{COLD}=((WC_{max}-WI_{max})/WI_{max})\times 100\%$$

3.8.3.2 Complete steps 3.8.2.1 through 3.8.2.4 for warm rinse. Calculate the remaining moisture content of the maximum test load for warm rinse, RMC_{WARM}, expressed as a percentage and defined as:

$$RMC_{WARM}=((WC_{max}-WI_{max})/WI_{max})\times 100\%$$

3.8.3.3 Calculate the remaining moisture content of the maximum test load, RMC_{max}, expressed as a percentage and defined as:

$$RMC_{max}=RMC_{COLD}\times(1-TUF_r)+RMC_{WARM}\times(TUF_r).$$

where:

TUF_r is the temperature use factor for warm rinse as defined in Table 4.1.1.

3.8.4 Clothes washers which have options that result in different RMC values, such as multiple selection of spin speeds or spin times, that are available in the energy test cycle, shall be tested at the maximum and minimum extremes of the available options, excluding any ''no spin'' (zero spin speed) settings, in accordance with requirements in 3.8.2 or 3.8.3. The calculated $RMC_{max\ extraction}$ and $RMC_{min\ extraction}$ at the maximum and minimum settings, respectively, shall be combined as follows and the final RMC to be used in section 4.3 shall be:

$$RMC = 0.75\times RMC_{max\ extraction}+0.25\times RMC_{min\ extraction}$$

4. Calculation of Derived Results From Test Measurements

4.1 *Hot water and machine electrical energy consumption of clothes washers.*

4.1.1 *Per-cycle temperature-weighted hot water consumption for maximum, average, and minimum water fill levels using each appropriate load size as defined in section 2.8 and Table 5.1.* Calculate for the cycle under test the per-cycle temperature weighted hot water consumption for the maximum water fill level, Vh_x, the average water fill level, Vh_a, and the minimum water fill level, Vh_n, expressed in gallons per cycle (or liters per cycle) and defined as:

(a) $Vh_x=[Hm_x\times TUF_m]+[Hh_x\times TUF_h]+[Hw_x\times TUF_w]+[Hc_x\times TUF_c]+[R_x\times TUF_r]$

(b) $Vh_a=[Hm_a\times TUF_m]+[Hh_a\times TUF_h]+[Hw_a\times TUF_w]+[Hc_a\times TUF_c]+[R_a\times TUF_r]$

(c) $Vh_n=[Hm_n\times TUF_m]+[Hh_n\times TUF_h]+[Hw_n\times TUF_w]+[Hc_n\times TUF_c]+[R_n\times TUF_r]$

where:

Hm_x, Hm_a, and Hm_n, are reported hot water consumption values, in gallons per-cycle (or liters per cycle), at maximum, average, and minimum water fill, respectively, for the extra-hot wash cycle with the appropriate test loads as defined in section 2.8.

Hh_x, Hh_a, and Hh_n, are reported hot water consumption values, in gallons per-cycle (or liters per cycle), at maximum, average, and minimum water fill, respectively, for the hot wash cycle with the appropriate test loads as defined in section 2.8.

Hw_x, Hw_a, and Hw_n, are reported hot water consumption values, in gallons per-cycle (or liters per cycle), at maximum, average, and minimum water fill, respectively, for the warm wash cycle with the appropriate test loads as defined in section 2.8.

Hc_x, Hc_a, and Hc_n, are reported hot water consumption values, in gallons per-cycle (or liters per cycle), at maximum, average, and minimum water fill, respectively, for the cold wash cycle with the appropriate test loads as defined in section 2.8.

R_x, R_a, and R_n are the reported hot water consumption values, in gallons per-cycle (or liters per cycle), at maximum, average, and minimum water fill, respectively, for the warm rinse cycle and the appropriate test loads as defined in section 2.8.

TUF_m, TUF_h, TUF_w, TUF_c, and TUF_r are temperature use factors for extra hot wash, hot wash, warm wash, cold wash, and warm rinse temperature selections, respectively, and are as defined in Table 4.1.1.

TABLE 4.1.1—TEMPERATURE USE FACTORS

Max Wash Temp Available	≤135 °F (57.2 °C)	≤135 °F (57.2 °C)	≤135 °F (57.2 °C)	>135 °F (57.2 °C)	>135 °F (57.2 °C)
No. Wash Temp Selections	Single	2 Temps	>2 Temps	3 Temps	>3 Temps
TUF_m (extra hot)	NA	NA	NA	0.14	0.05
TUF_h (hot)	NA	0.63	0.14	NA	0.09
TUF_w (warm)	NA	NA	0.49	0.49	0.49
TUF_c (cold)	1.00	0.37	0.37	0.37	0.37
TUF_r (warm rinse)	0.27	0.27	0.27	0.27	0.27

4.1.2 *Total per-cycle hot water energy consumption for all maximum, average, and minimum water fill levels tested.* Calculate the total per-cycle hot water energy consumption for the maximum water fill level, HE_{max}, the minimum water fill level, HE_{min}, and the average water fill level, HE_{avg}, expressed in kilowatt-hours per cycle and defined as:

(a) $HE_{max} = [Vh_x \times T \times K]$=Total energy when a maximum load is tested.

(b) $HE_{avg} = [Vh_a \times T \times K]$=Total energy when an average load is tested.

(c) $HE_{min} = [Vh_n \times T \times K]$=Total energy when a minimum load is tested.

where:

T=Temperature rise=75 °F (41.7 °C).

K=Water specific heat in kilowatt-hours per gallon degree F=0.00240 (0.00114 kWh/L-°C).

Vh_x Vh_a, and Vh_n, are as defined in 4.1.1.

4.1.3 *Total weighted per-cycle hot water energy consumption.* Calculate the total weighted per cycle hot water energy consumption, HE_T, expressed in kilowatt-hours per cycle and defined as:

$$HE_T=[HE_{max}\times F_{max}]+[HE_{avg}\times F_{avg}]+[HE_{mn}\times F_{min}]$$

where:

HE_{max}, HE_{avg}, and HE_{min} are as defined in 4.1.2.

F_{max}, F_{avg}, and F_{min} are the load usage factors for the maximum, average, and minimum test loads based on the size and type of control system on the washer being tested. The values are as shown in table 4.1.3.

TABLE 4.1.3—LOAD USAGE FACTORS

Water fill control system	Manual	Adaptive
F_{max} =	0.72 [1]	0.12 [2]
F_{avg} =	....	0.74 [2]
F_{min}=	0.28 [1]	0.14 [2]

[1] Reference 3.2.3.3.
[2] Reference 3.2.3.2.

4.1.4 *Total per-cycle hot water energy consumption using gas-heated or oil-heated water.* Calculate for the energy test cycle the per-cycle hot water consumption, HE_{TG}, using gas heated or oil-heated water, expressed in Btu per cycle (or megajoules per cycle) and defined as:

$HE_{TG}=H_T\times 1/e\times 3412$ Btu/kWh or $HE_{TG}=HE_T\times 1/e\times 3.6$ MJ/kWh

where:

e=Nominal gas or oil water heater efficiency=0.75.

HE_T=As defined in 4.1.3.

4.1.5 *Per-cycle machine electrical energy consumption for all maximum, average, and minimum test load sizes.* Calculate the total per-cycle machine electrical energy consumption for the maximum water fill level, ME_{max}, the minimum water fill level, ME_{min}, and the average water fill level, ME_{avg}, expressed in kilowatt-hours per cycle and defined as:

(a) $ME_{max}= [Em_x\times TUF_m]+ [Eh_x\times TUF_h]+ [Ew_x\times TUF_w]+ [Ec_x\times TUF_c]+ [ER_x\times TUF_r]$

(b) $ME_{avg}= [Em_a\times TUF_m]+ [Eh_a\times TUF_h]+ [Ew_a\times TUF_w]+ [Ec_a\times TUF_c]+ [ER_a\times TUF_r]$

(c) $ME_{min}= [Em_n\times TUF_m]+ [Eh_n\times TUF_h]+ [Ew_n\times TUF_w]+ [Ec_n\times xTUF_c]+ [ER_n\times TUF_r]$

where:

Em_x, Em_a, and Em_n, are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the extra-hot wash cycle.

Eh_x, Eh_a, and Eh_n, are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the hot wash cycle.

Ew_x, Ew_a, and Ew_n, are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the warm wash cycle.

Ec_x, Ec_a, and Ec_n, are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the cold wash cycle.

ER_x, ER_a, ER_n, are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the warm rinse cycle per definitions in 3.7.2 of this appendix.

TUF_m, TUF_h, TUF_w, TUF_c, and TUF_r are as defined in Table 4.1.1.

4.1.6 *Total weighted per-cycle machine electrical energy consumption.* Calculate the total per cycle load size weighted energy consumption, ME_T, expressed in kilowatt-hours per cycle and defined as:

$$ME_T=[ME_{max}\times F_{max}]+[ME_{avg}\times F_{avg}]+[ME_{min}\times F_{min}]$$

where:

ME_{max}, ME_{avg}, and ME_{min} are as defined in 4.1.5.

F_{max}, F_{avg}, and F_{min} are as defined in Table 4.1.3.

4.1.7 *Total per-cycle energy consumption when electrically heated water is used.* Calculate for the energy test cycle the total per-cycle energy consumption, E_{TE}, using electrical heated water, expressed in kilowatt-hours per cycle and defined as:

$$E_{TE}=HE_T+ME_T$$

where:

ME_T=As defined in 4.1.6.

HE_T=As defined in 4.1.3.

4.2 *Water consumption of clothes washers.* (The calculations in this Section need not be performed to determine compliance with the energy conservation standards for clothes washers.)

4.2.1 *Per-cycle water consumption.* Calculate the maximum, average, and minimum total water consumption, expressed in gallons per cycle (or liters per cycle), for the cold wash/cold rinse cycle and defined as:

$$Q_{max}=[Hc_x+Cc_x]$$
$$Q_{avg}=[Hc_a+Cc_a]$$
$$Q_{min}=[Hc_n+Cc_n]$$

where:

Hc_x, Cc_x, Hc_a, Cc_a, Hc_n, and Cc_n are as defined in 3.6.

4.2.2 *Total weighted per-cycle water consumption.* Calculate the total weighted per cycle consumption, Q_T, expressed in gallons per cycle (or liters per cycle) and defined as:

$$Q_T=[Q_{max}\times F_{max}]+[Q_{avg}\times F_{avg}]+[Q_{min}\times F_{min}]$$

where:

Q_{max}, Q_{avg}, and Q_{min} are as defined in 4.2.1.

F_{max}, F_{avg}, and F_{min} are as defined in table 4.1.3.

4.2.3 *Water consumption factor.* Calculate the water consumption factor, WCF, expressed in gallon per cycle per cubic feet (or liter per cycle per liter), as:

$$WCF=Q_T / C$$

where:

Q_T=as defined in section 4.2.2.

C = as defined in section 3.1.5.

4.3 *Per-cycle energy consumption for removal of moisture from test load.* Calculate the per-cycle energy required to remove the moisture of the test load, D_E, expressed in kilowatt-hours per cycle and defined as

$$D_E=(LAF)\times(\text{Maximum test load weight})\times(RMC—4\%)\times(DEF)\times(DUF)$$

where:

LAF=Load adjustment factor=0.52.

Test load weight=As required in 3.8.1, expressed in lbs/cycle.

RMC=As defined in 3.8.2.5, 3.8.3.3 or 3.8.4.

DEF=nominal energy required for a clothes dryer to remove moisture from clothes=0.5 kWh/lb (1.1 kWh/kg).

DUF=dryer usage factor, percentage of washer loads dried in a clothes dryer=0.84.

4.4 *Modified energy factor.* Calculate the modified energy factor, MEF, expressed in cubic feet per kilowatt-hour per cycle (or liters per kilowatt-hour per cycle) and defined as:

$$MEF=C/(E_{TE} + D_E)$$

where:

C=As defined in 3.1.5.

E_{TE}=As defined in 4.1.7.

D_E=As defined in 4.3.

4.5 *Energy factor.* Calculate the energy factor, EF, expressed in cubic feet per kilowatt-hour per cycle (or liters per kilowatt-hour per cycle) and defined as:

$$EF=C/E_{TE}$$

where:

C=As defined in 3.1.5.

E_{TE}=As defined in 4.1.7.

5. Test Loads

TABLE 5.1—TEST LOAD SIZES

Container volume		Minimum load		Maximum load		Average load	
cu. ft. ≥ <	(liter) ≥ <	lb	(kg)	lb	(kg)	lb	(kg)
0–0.8	0–22.7	3.00	1.36	3.00	1.36	3.00	1.36
0.80–0.90	22.7–25.5	3.00	1.36	3.50	1.59	3.25	1.47
0.90–1.00	25.5–28.3	3.00	1.36	3.90	1.77	3.45	1.56
1.00–1.10	28.3–31.1	3.00	1.36	4.30	1.95	3.65	1.66
1.10–1.20	31.1–34.0	3.00	1.36	4.70	2.13	3.85	1.75
1.20–1.30	34.0–36.8	3.00	1.36	5.10	2.31	4.05	1.84
1.30–1.40	36.8–39.6	3.00	1.36	5.50	2.49	4.25	1.93
1.40–1.50	39.6–42.5	3.00	1.36	5.90	2.68	4.45	2.02
1.50–1.60	42.5–45.3	3.00	1.36	6.40	2.90	4.70	2.13
1.60–1.70	45.3–48.1	3.00	1.36	6.80	3.08	4.90	2.22
1.70–1.80	48.1–51.0	3.00	1.36	7.20	3.27	5.10	2.31
1.80–1.90	51.0–53.8	3.00	1.36	7.60	3.45	5.30	2.40
1.90–2.00	53.8–56.6	3.00	1.36	8.00	3.63	5.50	2.49
2.00–2.10	56.6–59.5	3.00	1.36	8.40	3.81	5.70	2.59
2.10–2.20	59.5–62.3	3.00	1.36	8.80	3.99	5.90	2.68
2.20–2.30	62.3–65.1	3.00	1.36	9.20	4.17	6.10	2.77
2.30–2.40	65.1–68.0	3.00	1.36	9.60	4.35	6.30	2.86
2.40–2.50	68.0–70.8	3.00	1.36	10.00	4.54	6.50	2.95
2.50–2.60	70.8–73.6	3.00	1.36	10.50	4.76	6.75	3.06
2.60–2.70	73.6–76.5	3.00	1.36	10.90	4.94	6.95	3.15
2.70–2.80	76.5–79.3	3.00	1.36	11.30	5.13	7.15	3.24
2.80–2.90	79.3–82.1	3.00	1.36	11.70	5.31	7.35	3.33
2.90–3.00	82.1–85.0	3.00	1.36	12.10	5.49	7.55	3.42
3.00–3.10	85.0–87.8	3.00	1.36	12.50	5.67	7.75	3.52
3.10–3.20	87.8–90.6	3.00	1.36	12.90	5.85	7.95	3.61
3.20–3.30	90.6–93.4	3.00	1.36	13.30	6.03	8.15	3.70
3.30–3.40	93.4–96.3	3.00	1.36	13.70	6.21	8.35	3.79
3.40–3.50	96.3–99.1	3.00	1.36	14.10	6.40	8.55	3.88
3.50–3.60	99.1–101.9	3.00	1.36	14.60	6.62	8.80	3.99
3.60–3.70	101.9–104.8	3.00	1.36	15.00	6.80	9.00	4.08
3.70–3.80	104.8–107.6	3.00	1.36	15.40	6.99	9.20	4.17

NOTES: (1) All test load weights are bone dry weights.
(2) Allowable tolerance on the test load weights are ±0.10 lbs (0.05 kg).

6. *Waivers and Field Testing*

6.1 *Waivers and Field Testing for Non-conventional Clothes Washers.* Manufacturers of nonconventional clothes washers, such as clothes washers with adaptive control systems, must submit a petition for waiver pursuant to 10 CFR 430.27 to establish an acceptable test procedure for that clothes washer. For these and other clothes washers that have controls or systems such that the DOE test procedures yield results that are so unrepresentative of the clothes washer's true energy consumption characteristics as to provide materially inaccurate comparative data, field testing may be appropriate for establishing an acceptable test procedure. The following are guidelines for field testing which may be used by manufacturers in support of petitions for waiver. These guidelines are not mandatory and the Department may determine that they do not apply to a particular model. Depending upon a manufacturer's approach for conducting field testing, additional data may be required. Manufacturers are encouraged to communicate with the Department prior to the commencement of field tests which may be used to support a petition for waiver. Section 6.3 provides an example of field testing for a clothes washer with an adaptive water fill control system. Other features, such as the use of various spin speed selections, could be the subject of field tests.

6.2 *Nonconventional Wash System Energy Consumption Test.* The field test may consist of a minimum of 10 of the nonconventional clothes washers (''test clothes washers'') and 10 clothes washers already being distributed in commerce (''base clothes washers''). The tests should include a minimum of 50 energy test cycles per clothes washer. The test clothes washers and base clothes washers should be identical in construction except for the controls or systems being tested. Equal numbers of both the test clothes washer and the base clothes washer should be tested simultaneously in comparable settings to minimize seasonal or consumer laundering conditions or variations. The clothes washers should be monitored in such a way as to accurately record the total energy consumption per cycle. At a minimum, the following should be measured and recorded throughout the test period for each clothes washer: Hot water usage in gallons (or liters), electrical energy usage in kilowatt-hours, and the cycles of usage.

The field test results would be used to determine the best method to correlate the rating of the test clothes washer to the rating of the base clothes washer. If the base clothes washer is rated at A kWh per year, but field tests at B kWh per year, and the test clothes washer field tests at D kWh per year, the test unit would be rated as follows:

$A\times(D/B)=G$ kWh per year

6.3 *Adaptive water fill control system field test.* Section 3.2.3.1 defines the test method for measuring energy consumption for clothes washers which incorporate control systems having both adaptive and alternate cycle selections. Energy consumption calculated by the method defined in section 3.2.3.1 assumes the adaptive cycle will be used 50 percent of the time. This section can be used to develop field test data in support of a petition for waiver when it is believed that the adaptive cycle will be used more than 50 percent of the time. The field test sample size should be a minimum of 10 test clothes washers. The test clothes washers should be totally representative of the design, construction, and control system that will be placed in commerce. The duration of field testing in the user's house should be a minimum of 50 energy test cycles, for each unit. No special instructions as to cycle selection or product usage should be given to the field test participants, other than inclusion of the product literature pack which would be shipped with all units, and instructions regarding filling out data collection forms, use of data collection equipment, or basic procedural methods. Prior to the test clothes washers being installed in the field test locations, baseline data should be developed for all field test units by conducting laboratory tests as defined by section 1 through section 5 of these test procedures to determine the energy consumption, water consumption, and remaining moisture content values. The following data should be measured and recorded for each wash load during the test period: wash cycle selected, the mode of the clothes washer (adaptive or manual), clothes load dry weight (measured after the clothes washer and clothes dryer cycles are completed) in pounds, and type of articles in the clothes load (e.g., cottons, linens, permanent press). The wash loads used in calculating the in-home percentage split between adaptive and manual cycle usage should be only those wash loads which conform to the definition of the energy test cycle.

Calculate:

T=The total number of energy test cycles run during the field test

T_a=The total number of adaptive control energy test cycles

T_m=The total number of manual control energy test cycles

The percentage weighting factors:

$P_a=(T_a/T)\times100$ (the percentage weighting for adaptive control selection)

$P_m=(T_m/T)\times100$ (the percentage weighting for manual control selection)

Energy consumption (HE_T, ME_T, and D_E) and water consumption (Q_T), values calculated in section 4 for the manual and adaptive modes, should be combined using P_a and P_m as the weighting factors.

[62 FR 45508, Aug. 27, 1997; 63 FR 16669, Apr. 6, 1998, as amended at 66 FR 3330, Jan. 12, 2001; 68 FR 62204, Oct. 31, 2003; 69 FR 18803, Apr. 9, 2004]

APPENDIXES K–L TO SUBPART B OF PART 430 [RESERVED]

APPENDIX M TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF CENTRAL AIR CONDITIONERS AND HEAT PUMPS

NOTE: The procedures and calculations that refer to off mode energy consumption (*i.e.*, sections 3.13 and 4.2.8 of this appendix M) need not be performed to determine compliance with energy conservation standards for central air conditioners and heat pumps at this time. However, any representation related to standby mode and off mode energy consumption of these products made after corresponding revisions to the central air conditioners and heat pumps test procedure must be based upon results generated under this test procedure, consistent with the requirements of 42 U.S.C. 6293(c)(2). For residential central air conditioners and heat pumps manufactured on or after January 1, 2015, compliance with the applicable provisions of this test procedure is required in order to determine compliance with energy conservation standards.

1. DEFINITIONS

2. TESTING CONDITIONS

2.1 Test room requirements.

2.2 Test unit installation requirements.

2.2.1 Defrost control settings.

2.2.2 Special requirements for units having a multiple-speed outdoor fan.

2.2.3 Special requirements for multi-split air conditioners and heat pumps, and systems composed of multiple mini-split units (outdoor units located side-by-side) that would normally operate using two or more indoor thermostats.

2.2.4 Wet-bulb temperature requirements for the air entering the indoor and outdoor coils.

2.2.4.1 Cooling mode tests.

2.2.4.2 Heating mode tests.

fixed speed indoor fan installed, with a constant-air-volume-rate indoor fan installed, or with no indoor fan installed.

3.6.2 Tests for a heat pump having a single-speed compressor and a variable-speed, variable-air-volume-rate indoor fan: capacity modulation correlates with outdoor dry bulb temperature.

3.6.3 Tests for a heat pump having a two-capacity compressor (see Definition 1.45), including two-capacity, northern heat pumps (see Definition 1.46).

3.6.4 Tests for a heat pump having a variable-speed compressor.

3.6.5 Additional test for a heat pump having a heat comfort controller.

3.7 Test procedures for steady-state Maximum Temperature and High Temperature heating mode tests (the $H0_1$, H1, $H1_2$, $H1_1$, and $H1_N$ Tests).

3.8 Test procedures for the optional cyclic heating mode tests (the $H0C_1$, H1C, and $H1C_1$ Tests).

3.8.1 Heating mode cyclic degradation coefficient calculation.

3.9 Test procedures for Frost Accumulation heating mode tests (the H_2, $H2_2$, $H2_V$, and $H2_1$ Tests).

3.9.1 Average space heating capacity and electrical power calculations.

3.9.2 Demand defrost credit.

3.10 Test procedures for steady-state Low Temperature heating mode tests (the H_3, $H3_2$, and $H3_1$ Tests).

3.11 Additional requirements for the secondary test methods.

3.11.1 If using the Outdoor Air Enthalpy Method as the secondary test method.

3.11.1.1 If a preliminary test precedes the official test

3.11.1.2 If a preliminary test does not precede the official test.

3.11.1.3 Official test.

3.11.2 If using the Compressor Calibration Method as the secondary test method.

3.11.3 If using the Refrigerant Enthalpy Method as the secondary test method.

3.12 Rounding of space conditioning capacities for reporting purposes.

4. CALCULATIONS OF SEASONAL PERFORMANCE DESCRIPTORS

4.1 Seasonal Energy Efficiency Ratio (SEER) Calculations.

4.1.1 SEER calculations for an air conditioner or heat pump having a single-speed compressor that was tested with a fixed-speed indoor fan installed, a constant-air-volume-rate indoor fan installed, or with no indoor fan installed.

4.1.2 SEER calculations for an air conditioner or heat pump having a single-speed compressor and a variable-speed variable-air-volume-rate indoor fan.

4.1.2.1 Units covered by section 3.2.2.1 where indoor fan capacity modulation correlates with the outdoor dry bulb temperature.

4.1.2.2 Units covered by section 3.2.2.2 where indoor fan capacity modulation is used to adjust the sensible to total cooling capacity ratio.

4.1.3 SEER calculations for an air conditioner or heat pump having a two-capacity compressor.

4.1.3.1 Steady-state space cooling capacity at low compressor capacity is greater than or equal to the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) \geq BL(T_j)$.

4.1.3.2 Unit alternates between high (k=2) and low (k=1) compressor capacity to satisfy the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

4.1.3.3 Unit only operates at high (k=2) compressor capacity at temperature T_j and its capacity is greater than the building cooling load, $BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

4.1.3.4 Unit must operate continuously at high (k=2) compressor capacity at temperature T_j, $BL(T_j) \geq \dot{Q}_c^{k=2}(T_j)$.

4.1.4 SEER calculations for an air conditioner or heat pump having a variable-speed compressor.

4.1.4.1 Steady-state space cooling capacity when operating at minimum compressor speed is greater than or equal to the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) \geq BL(T_j)$.

4.1.4.2 Unit operates at an intermediate compressor speed (k=i) in order to match the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

4.1.4.3 Unit must operate continuously at maximum (k=2) compressor speed at temperature T_j, $BL(T_j) \geq \dot{Q}_c^{k=2}(T_j)$.

4.2 Heating Seasonal Performance Factor (HSPF) Calculations.

4.2.1 Additional steps for calculating the HSPF of a heat pump having a single-speed compressor that was tested with a fixed-speed indoor fan installed, a constant-air-volume-rate indoor fan installed, or with no indoor fan installed.

4.2.2 Additional steps for calculating the HSPF of a heat pump having a single-speed compressor and a variable-speed, variable-air-volume-rate indoor fan.

4.2.3 Additional steps for calculating the HSPF of a heat pump having a two-capacity compressor.

4.2.3.1 Steady-state space heating capacity when operating at low compressor capacity is greater than or equal to the building heating load at temperature T_j, $\dot{Q}_h^{k=1}(T_j) \geq BL(T_j)$.

4.2.3.2 Heat pump alternates between high (k=2) and low (k=1) compressor capacity to satisfy the building heating load at a temperature T_j, $\dot{Q}_h^{k=1}(T_j)\ BL(T_j) < \dot{Q}_h^{k=2}(T_j)$.

4.2.3.3 Heat pump only operates at high (k=2) compressor capacity at temperature T_j and its capacity is greater than the building heating load, $BL(T_j) < \dot{Q}_h^{k=2}(T_j)$.

4.2.3.4 Heat pump must operate continuously at high (k=2) compressor capacity at temperature T_j, $BL(T_j) \geq \dot{Q}_h^{k=2}(T_j)$.

4.2.4 Additional steps for calculating the HSPF of a heat pump having a variable-speed compressor.

4.2.4.1 Steady-state space heating capacity when operating at minimum compressor speed is greater than or equal to the building heating load at temperature T_j, $\dot{Q}_h^{k=1}(T_j) \geq BL(T_j)$.

4.2.4.2 Heat pump operates at an intermediate compressor speed (k=i) in order to match the building heating load at a temperature T_j, $\dot{Q}_h^{k=1}(T_j) < BL(T_j) < \dot{Q}_h^{k=2}(T_j)$.

4.2.4.3 Heat pump must operate continuously at maximum (k=2) compressor speed at temperature T_j, $BL(T_j) \geq \dot{Q}_h^{k=2}(T_j)$.

4.2.5 Heat pumps having a heat comfort controller.

4.2.5.1 Heat pump having a heat comfort controller: Additional steps for calculating the HSPF of a heat pump having a single-speed compressor that was tested with a fixed-speed indoor fan installed, a constant-air-volume-rate indoor fan installed, or with no indoor fan installed.

4.2.5.2 Heat pump having a heat comfort controller: Additional steps for calculating the HSPF of a heat pump having a single-speed compressor and a variable-speed, variable-air-volume-rate indoor fan.

4.2.5.3 Heat pumps having a heat comfort controller: Additional steps for calculating the HSPF of a heat pump having a two-capacity compressor.

4.2.5.4 Heat pumps having a heat comfort controller: Additional steps for calculating the HSPF of a heat pump having a variable-speed compressor. [Reserved]

4.3 Calculations of the Actual and Representative Regional Annual Performance Factors for Heat Pumps.

4.3.1 Calculation of actual regional annual performance factors (APF_A) for a particular location and for each standardized design heating requirement.

4.3.2 Calculation of representative regional annual performance factors (APF_R) for each generalized climatic region and for each standardized design heating requirement.

4.4 Rounding of SEER, HSPF, and APF for reporting purposes.

1. Definitions

1.1 Annual performance factor means the total heating and cooling done by a heat pump in a particular region in one year divided by the total electric energy used in one year. Paragraph (m)(3)(iii) of §430.23 of the Code of Federal Regulations states the calculation requirements for this rating descriptor.

1.2 ARI means Air-Conditioning and Refrigeration Institute.

1.3 ARI Standard 210/240–2006 means the test standard ''Unitary Air-Conditioning and Air-Source Heat Pump Equipment'' published in 2006 by ARI.

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

1.5 ASHRAE Standard 23–2005 means the test standard ''Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units'' published in 2005 by ASHRAE.

1.6 ASHRAE Standard 37–2005 means the test standard ''Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment'' published in 2005 by ASHRAE.

1.7 ASHRAE Standard 41.1–86 (RA 01) means the test standard ''Standard Method for Temperature Measurement'' published in 1986 and reaffirmed in 2001 by ASHRAE.

1.8 ASHRAE Standard 41.2–87 (RA 92) means the test standard ''Standard Methods for Laboratory Airflow Measurement'' published in 1987 and reaffirmed in 1992 by ASHRAE.

1.9 ASHRAE Standard 41.6–94 (RA 01) means the test standard ''Method for Measurement of Moist Air Properties'' published in 1994 and reaffirmed in 2001 by ASHRAE.

1.10 ASHRAE Standard 41.9–00 means the test standard ''Calorimeter Test Methods for Mass Flow Measurements of Volatile Refrigerants'' published in 2000 by ASHRAE.

1.11 ASHRAE Standard 51–99/AMCA Standard 210–1999 means the test standard ''Laboratory Methods of Testing Fans for Aerodynamic Performance Rating'' published in 1999 by ASHRAE and the Air Movement and Control Association International, Inc.

1.12 ASHRAE Standard 116–95 RA(05) means the test standard ''Methods of Testing for Rating for Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps'' published in 1995 and reaffirmed in 2005 by ASHRAE.

1.13 CFR means Code of Federal Regulations.

1.14 Constant-air-volume-rate indoor fan means a fan that varies its operating speed to provide a fixed air-volume-rate from a ducted system.

1.15 Continuously recorded, when referring to a dry bulb measurement, means that the specified temperature must be sampled at regular intervals that are equal to or less than the maximum intervals specified in section 4.3 part ''a'' of ASHRAE Standard 41.1–86 (RA 01). If such dry bulb temperatures are used only for test room control, it means that one samples at regular intervals equal to or less than the maximum intervals specified in section 4.3 part ''b'' of the same ASHRAE Standard. Regarding wet bulb temperature, dew point temperature, or relative humidity measurements, continuously recorded means that the measurements must be made at regular intervals that are equal to or less than 1 minute.

1.16 Cooling load factor (CLF) means the ratio having as its numerator the total cooling delivered during a cyclic operating interval consisting of one ON period and one OFF period. The denominator is the total cooling that would be delivered, given the same ambient conditions, had the unit operated continuously at its steady-state space cooling capacity for the same total time (ON + OFF) interval.

1.17 Coefficient of Performance (COP) means the ratio of the average rate of space heating delivered to the average rate of electrical energy consumed by the heat pump. These rate quantities must be determined from a single test or, if derived via interpolation, must be tied to a single set of operating conditions. COP is a dimensionless quantity. When determined for a ducted unit tested without an indoor fan installed, COP must include the section 3.7, 3.8, and 3.9.1 default values for the heat output and power input of a fan motor.

1.18 Cyclic Test means a test where the unit's compressor is cycled on and off for specific time intervals. A cyclic test provides half the information needed to calculate a degradation coefficient.

1.19 Damper box means a short section of duct having an air damper that meets the performance requirements of section 2.5.7.

1.20 Degradation coefficient (C_D) means a parameter used in calculating the part load factor. The degradation coefficient for cooling is denoted by C_D^c. The degradation coefficient for heating is denoted by C_D^h.

1.21 Demand-defrost control system means a system that defrosts the heat pump outdoor coil only when measuring a predetermined degradation of performance. The heat pump's controls monitor one or more parameters that always vary with the amount of frost accumulated on the outdoor coil (*e.g.*, coil to air differential temperature, coil differential air pressure, outdoor fan power or current, optical sensors, etc.) at least once for every ten minutes of compressor ON-time when space heating. One acceptable alternative to the criterion given in the prior sentence is a feedback system that measures the length of the defrost period and adjusts defrost frequency accordingly.[1] In all cases, when the frost parameter(s) reaches a predetermined value, the system initiates a defrost. In a demand-defrost control system, defrosts are terminated based on monitoring a parameter(s) that indicates that frost has been eliminated from the coil.

A demand-defrost control system, which otherwise meets the above requirements, may allow time-initiated defrosts if, and only if, such defrosts occur after 6 hours of compressor operating time.

1.22 Design heating requirement (DHR) predicts the space heating load of a residence when subjected to outdoor design conditions. Estimates for the minimum and maximum DHR are provided for six generalized U.S. climatic regions in section 4.2.

1.23 Dry-coil tests are cooling mode tests where the wet-bulb temperature of the air supplied to the indoor coil is maintained low enough that no condensate forms on this coil.

1.24 Ducted system means an air conditioner or heat pump that is designed to be permanently installed equipment and delivers conditioned air to the indoor space through a duct(s). The air conditioner or heat pump may be either a split system or a single-packaged unit.

1.25 Energy efficiency ratio (EER) means the ratio of the average rate of space cooling delivered to the average rate of electrical energy consumed by the air conditioner or heat pump. These rate quantities must be determined from a single test or, if derived via interpolation, must be tied to a single set of operating conditions. EER is expressed in units of

$$\frac{\text{Btu/h}}{\text{W}}.$$

When determined for a ducted unit tested without an indoor fan installed, EER must include the section 3.3 and 3.5.1 default values for the heat output and power input of a fan motor.

1.26 Heating load factor (HLF) means the ratio having as its numerator the total heating delivered during a cyclic operating interval consisting of one ON period and one OFF period. The denominator is the total heating that would be delivered, given the same ambient conditions, if the unit operated continuously at its steady-state space heating capacity for the same total time (ON plus OFF) interval.

1.27 Heating seasonal performance factor (HSPF) means the total space heating required during the space heating season, expressed in Btu's, divided by the total electrical energy consumed by the heat pump system during the same season, expressed in watt-hours. The HSPF used to evaluate compliance with the Energy Conservation Standards (see 10 CFR 430.32(c), subpart C) is based on Region IV, the minimum standardized design heating requirement, and the sampling plan stated in 10 CFR 430.24(m), subpart B.

1.28 Heat pump having a heat comfort controller means equipment that regulates the operation of the electric resistance elements to assure that the air temperature leaving the indoor section does not fall below

[1] Systems that vary defrost intervals according to outdoor dry-bulb temperature are not demand defrost systems.

a specified temperature. This specified temperature is usually field adjustable. Heat pumps that actively regulate the rate of electric resistance heating when operating below the balance point (as the result of a second stage call from the thermostat) but do not operate to maintain a minimum delivery temperature are not considered as having a heat comfort controller.

1.29 Mini-split air conditioners and heat pumps means systems that have a single outdoor section and one or more indoor sections. The indoor sections cycle on and off in unison in response to a single indoor thermostat.

1.30 Multiple-split air conditioners and heat pumps means systems that have two or more indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats.

1.31 Non-ducted system means an air conditioner or heat pump that is designed to be permanently installed equipment and directly heats or cools air within the conditioned space using one or more indoor coils that are mounted on room walls and/or ceilings. The unit may be of a modular design that allows for combining multiple outdoor coils and compressors to create one overall system. Non-ducted systems covered by this test procedure are all split systems.

1.32 Part-load factor (PLF) means the ratio of the cyclic energy efficiency ratio (coefficient of performance) to the steady-state energy efficiency ratio (coefficient of performance). Evaluate both energy efficiency ratios (coefficients of performance) based on operation at the same ambient conditions.

1.33 Seasonal energy efficiency ratio (SEER) means the total heat removed from the conditioned space during the annual cooling season, expressed in Btu's, divided by the total electrical energy consumed by the air conditioner or heat pump during the same season, expressed in watt-hours. The SEER calculation in section 4.1 of this appendix and the sampling plan stated in 10 CFR subpart B, 430.24(m) are used to evaluate compliance with the Energy Conservation Standards. (See 10 CFR 430.32(c), subpart C.)

1.34 Single-packaged unit means any central air conditioner or heat pump that has all major assemblies enclosed in one cabinet.

1.35 Small-duct, high-velocity system means a system that contains a blower and indoor coil combination that is designed for, and produces, at least 1.2 inches (of water) of external static pressure when operated at the full-loadair volume rate of 220–350 cfm per rated ton of cooling. When applied in the field, small-duct products use high-velocity room outlets (*i.e.*, generally greater than 1000 fpm) having less than 6.0 square inches of free area.

1.36 Split system means any air conditioner or heat pump that has one or more of the major assemblies separated from the others.

1.37 Standard Air means dry air having a mass density of 0.075 lb/ft^3.

1.38 Steady-state test means a test where the test conditions are regulated to remain as constant as possible while the unit operates continuously in the same mode.

1.39 Temperature bin means the 5 °F increments that are used to partition the outdoor dry-bulb temperature ranges of the cooling (≥ 65 °F) and heating (< 65 °F) seasons.

1.40 Test condition tolerance means the maximum permissible difference between the average value of the measured test parameter and the specified test condition.

1.41 Test operating tolerance means the maximum permissible range that a measurement may vary over the specified test interval. The difference between the maximum and minimum sampled values must be less than or equal to the specified test operating tolerance.

1.42 Time adaptive defrost control system is a demand-defrost control system (see definition 1.21) that measures the length of the prior defrost period(s) and uses that information to automatically determine when to initiate the next defrost cycle.

1.43 Time-temperature defrost control systems initiate or evaluate initiating a defrost cycle only when a predetermined cumulative compressor ON-time is obtained. This predetermined ON-time is generally a fixed value (*e.g.*, 30, 45, 90 minutes) although it may vary based on the measured outdoor dry-bulb temperature. The ON-time counter accumulates if controller measurements (*e.g.*, outdoor temperature, evaporator temperature) indicate that frost formation conditions are present, and it is reset/remains at zero at all other times. In one application of the control scheme, a defrost is initiated whenever the counter time equals the predetermined ON-time. The counter is reset when the defrost cycle is completed.

In a second application of the control scheme, one or more parameters are measured (*e.g.*, air and/or refrigerant temperatures) at the predetermined, cumulative, compressor ON-time. A defrost is initiated only if the measured parameter(s) falls within a predetermined range. The ON-time counter is reset regardless of whether a defrost is initiated. If systems of this second type use cumulative ON-time intervals of 10 minutes or less, then the heat pump may qualify as having a demand defrost control system (see definition 1.21).

1.44 Triple-split system means an air conditioner or heat pump that is composed of three separate components: An outdoor fan coil section, an indoor fan coil section, and an indoor compressor section.

1.45 Two-capacity (or two-stage) compressor means an air conditioner or heat pump that has one of the following:

(1) A two-speed compressor,

(2) Two compressors where only one compressor ever operates at a time,

(3) Two compressors where one compressor (Compressor #1) operates at low loads and both compressors (Compressors #1 and #2) operate at high loads but Compressor #2 never operates alone, or

(4) A compressor that is capable of cylinder or scroll unloading.

For such systems, low capacity means:

(1) Operating at low compressor speed,

(2) Operating the lower capacity compressor,

(3) Operating Compressor #1, or

(4) Operating with the compressor unloaded (*e.g.*, operating one piston of a two-piston reciprocating compressor, using a fixed fractional volume of the full scroll, etc.).

For such systems, high capacity means:

(1) Operating at high compressor speed,

(2) Operating the higher capacity compressor,

(3) Operating Compressors #1 and #2, or

(4) Operating with the compressor loaded (*e.g.*, operating both pistons of a two-piston reciprocating compressor, using the full volume of the scroll).

1.46 Two-capacity, northern heat pump means a heat pump that has a factory or field-selectable lock-out feature to prevent space cooling at high-capacity. Two-capacity heat pumps having this feature will typically have two sets of ratings, one with the feature disabled and one with the feature enabled. The indoor coil model number should reflect whether the ratings pertain to the lockout enabled option via the inclusion of an extra identifier, such as ''+LO.'' When testing as a two-capacity, northern heat pump, the lockout feature must remain enabled for all tests.

1.47 Wet-coil test means a test conducted at test conditions that typically cause water vapor to condense on the test unit evaporator coil.

2. Testing Conditions

This test procedure covers split-type and single-packaged ducted units and split-type non-ducted units. Except for units having a variable-speed compressor, ducted units tested without an indoor fan installed are covered.

a. Only a subset of the sections listed in this test procedure apply when testing and rating a particular unit. Tables 1–A through 1–C show which sections of the test procedure apply to each type of equipment. In each table, look at all four of the Roman numeral categories to see what test sections apply to the equipment being tested.

1. The first category, Rows I–1 through I–4 of the Tables, pertains to the compressor and indoor fan features of the equipment. After identifying the correct ''I'' row, find the table cells in the same row that list the type of equipment being tested: Air conditioner (AC), heat pump (HP), or heating-only heat pump (HH). Use the test section(s) listed above each noted table cell for testing and rating the unit.

2. The second category, Rows II–1 and II–2, pertains to the presence or absence of ducts. Row II–1 shows the test procedure sections that apply to ducted systems, and Row II–2 shows those that apply to non-ducted systems.

3. The third category is for special features that may be present in the equipment. When testing units that have one or more of the three (special) equipment features described by the Table legend for Category III, use Row III to find test sections that apply.

4. The fourth category is for the secondary test method to be used. If the secondary method for determining the unit's cooling and/or heating capacity is known, use Row IV to find the appropriate test sections. Otherwise, include all of the test sections referenced by Row IV cell entries—*i.e.*, sections 2.10 to 2.10.3 and 3.11 to 3.11.3—among those sections consulted for testing and rating information.

b. Obtain a complete listing of all pertinent test sections by recording those sections identified from the four categories above.

c. The user should note that, for many sections, only part of a section applies to the unit being tested. In a few cases, the entire section may not apply. For example, sections 3.4 to 3.5.3 (which describe optional dry coil tests), are not relevant if the allowed default value for the cooling mode cyclic degradation coefficient is used rather than determining it by testing.

Example for Using Tables 1–A to 1–C

Equipment Description: A ducted air conditioner having a single-speed compressor, a fixed-speed indoor fan, and a multi-speed outdoor fan.

Secondary Test Method: Refrigerant Enthalpy Method

Step 1. Determine which of four listed Row ''I'' options applies ==> Row I–2

Table 1–A: ''AC'' in Row I–2 is found in the columns for sections 1.1 to 1.47, 2.1 to 2.2, 2.2.4 to 2.2.4.1, 2.2.5, 2.3 to 2.3.1, 2.4 to 2.4.1, 2.5, 2.5.2 to 2.10, and 2.11 to 2.13.

Table 1–B: ''AC'' is listed in Row I–2 for sections 3 to 3.1.4, 3.1.5 to 3.1.8, 3.2.1, 3.3 to 3.5, 3.5.3, 3.11 and 3.12.

Table 1–C: ''AC'' is listed in Row I–2 for sections 4.1.1 and 4.4.

Step 2. Equipment is ducted ==> Row II–1

Table 1–A: ''AC'' is listed in Row II–1 for sections 2.4.2 and 2.5.1 to 2.5.1.2.

Table 1–B: "AC" is listed in Row II–1 for sections 3.1.4.1 to 3.1.4.1.1 and 3.5.1.

Table 1–C: no "AC" listings in Row II–1.

Step 3. Equipment Special Features include multi-speed outdoor fan ==> Row III, M

Table 1–A: "M" is listed in Row III for section 2.2.2

Tables 1–B and 1–C: no "M" listings in Row III.

Step 4. Secondary Test Method is Refrigerant Enthalpy Method ==> Row IV, R

Table 1–A: "R" is listed in Row IV for section 2.10.3

Table 1–B: "R" is listed in Row IV for section 3.11.3

Table 1–C: no "R" listings in Row IV.

Step 5. Cumulative listing of applicable test procedure sections 1.1 to 1.47, 2.1 to 2.2, 2.2.2, 2.2.4 to 2.4.1, 2.2.5, 2.3 to 2.3.1, 2.4 to 2.4.1, 2.4.2, 2.5, 2.5.1 to 2.5.1.2, 2.5.2 to 2.10, 2.10.3, 2.11 to 2.13, 3. to 3.1.4, 3.1.4.1 to 3.1.4.1.1, 3.1.5 to 3.1.8, 3.2.1, 3.3 to 3.5, 3.5.1, 3.5.3, 3.11, 3.11.3, 3.12, 4.1.1, and 4.4.

Table 1A. Selection of Test Procedure Sections: Section 1 (Definitions) and Section 2 (Testing Conditions)

Key Equipment Features and Secondary Test Method \ Sections From the Test Procedure	1.1 to 1.47	2.1 to 2.2	2.2.1	2.2.2	2.2.3	2.2.4 to 2.2.4.1	2.2.4.2	2.2.5	2.3 to 2.3.1	2.3.2	2.4 to 2.4.1	2.4.2	2.5	2.5.1 to 2.5.1.2	2.5.2 to 2.10	2.10.1	2.10.2	2.10.3	2.11 to 2.13
I-1. Single-speed Compressor; Variable-Speed Variable Air Volume Indoor Fan	AC HP HH	AC HP HH	HP HH			AC HP	HP HH	AC HP HH	AC HP	HP HH	AC HP HH		AC HP HH		AC HP HH				AC HP HH
I-2. Single-speed Compressor Except as Covered by "I-1"	AC HP HH	AC HP HH	HP HH			AC HP	HP HH	AC HP HH	AC HP	HP HH	AC HP HH		AC HP HH		AC HP HH				AC HP HH
I-3. Two-capacity Compressor	AC HP HH	AC HP HH	HP HH			AC HP	HP HH	AC HP HH	AC HP	HP HH	AC HP HH		AC HP HH		AC HP HH				AC HP HH
I-4. Variable-speed Compressor	AC HP HH	AC HP HH	HP HH			AC HP	HP HH	AC HP HH	AC HP	HP HH	AC HP HH		AC HP HH		AC HP HH				AC HP HH
II-1. Ducted												AC HP HH		AC HP HH					
II-2. Non-Ducted																			
III. Special Features				M	G														
IV. Secondary Test Method																O	C	R	

Legend for Table Entries:

Categories I and II: AC = applies for an Air Conditioner that meets the corresponding Column 1 "Key Equipment . . ." criterion
HP = applies for a Heat Pump that meets the corresponding Column 1 "Key Equipment . . ." criterion
HH = applies for a Heating-only Heat pump that meets the corresponding Column 1 "Key Equipment . . ." criterion

Category III: G = ganged mini-splits or multi-splits;
H = heat pump with a heat comfort controller;
M = units with a multi-speed outdoor fan.

Category IV: O = Outdoor Air Enthalpy Method; C = Compressor Calibration Method; R = Refrigerant Enthalpy Method

Table 1B. Selection of Test Procedure Sections: Section 3 (Testing Procedures)

Key Equipment Features and Secondary Test Method \ Sections From the Test Procedure	3. to 3.1.4	3.1.4.1 to 3.1.4.1.1	3.1.4.1.2	3.1.4.2	3.1.4.3	3.1.4.4 to 3.1.4.4.2	3.1.4.4.3	3.1.4.4.4	3.1.4.5	3.1.4.6 to 3.1.4.7	3.1.5 to 3.1.8	3.1.9	3.2.1	3.2.2 to 3.2.2.2	3.2.3	3.2.4	3.3 to 3.5	3.5.1	3.5.2	3.5.3
I-1. Single-speed Compressor; Variable-speed, Variable Air Volume Indoor Fan	AC HP HH			AC HP					HP HH		AC HP HH	HP HH		AC HP			AC HP			AC HP
I-2. Single-speed Compressor Except as Covered by "I-1"	AC HP HH										AC HP HH	HP HH	AC HP				AC HP			AC HP
I-3. Two-capacity Compressor	AC HP HH			AC HP					HP HH		AC HP HH	HP HH			AC HP		AC HP			AC HP
I-4. Variable-speed Compressor	AC HP HH			AC HP	AC HP				HP HH	HP HH	AC HP HH	HP HH				AC HP	AC HP			AC HP
II-1. Ducted		AC HP				HP	HH											AC HP		
II-2. Non-Ducted			AC HP					HP HH											AC HP	
III. Special Features												H								
IV. Secondary Test Method																				

Legend for Table Entries:

Categories I and II: AC = applies for an Air Conditioner that meets the corresponding Column 1 "Key Equipment . . ." criterion
HP = applies for a Heat Pump that meets the corresponding Column 1 "Key Equipment . . ." criterion
HH = applies for a Heating-only Heat pump that meets the corresponding Column 1 "Key Equipment . . ." criterion

Category III: G = ganged mini-splits or multi-splits;
H = heat pump with a heat comfort controller;
M = units with a multi-speed outdoor fan.

Category IV: O = Outdoor Air Enthalpy Method; C = Compressor Calibration Method; R = Refrigerant Enthalpy Method

Table 1B. Selection of Test Procedure Sections: Section 3 (Testing Procedures) (continued)

Key Equipment Features and Secondary Test Method \ Sections From the Test Procedure	3.6.1	3.6.2	3.6.3	3.6.4	3.6.5	3.7 to 3.8.1	3.9 to 3.10	3.11	3.11.1 to 3.11.1.3	3.11.2	3.11.3	3.12
I-1. Single-speed Compressor; Variable-speed, Variable Air Volume Indoor Fan		HP HH				HP HH	HP HH	AC HP HH				AC HP HH
I-2. Single-speed Compressor Except as Covered by "I-1"	HP HH					HP HH	HP HH	AC HP HH				AC HP HH
I-3. Two-capacity Compressor			HP HH			HP HH	HP HH	AC HP HH				AC HP HH
I-4. Variable-speed Compressor				HP HH		HP HH	HP HH	AC HP HH				AC HP HH
II-1. Ducted												
II-2. Non-Ducted												
III. Special Features					H							
IV. Secondary Test Method									O	C	R	

Legend for Table Entries:

Categories I and II: AC = applies for an Air Conditioner that meets the corresponding Column 1 "Key Equipment . . ." criterion

HP = applies for a Heat Pump that meets the corresponding Column 1 "Key Equipment . . ." criterion

HH = applies for a Heating-only Heat pump that meets the corresponding Column 1 "Key Equipment . . ." criterion

Category III: G = ganged mini-splits or multi-splits;

H = heat pump with a heat comfort controller;

M = units with a multi-speed outdoor fan.

Category IV: O = Outdoor Air Enthalpy Method; C = Compressor Calibration Method; R = Refrigerant Enthalpy Method

Table 1C. Selection of Test Procedure Sections: Section 4 (Calculations of Seasonal Performance Descriptors)

Key Equipment Features and Secondary Test Method / Sections From the Test Procedure	4 to 4.1	4.1.1	4.1.2 to 4.1.2.2	4.1.3 to 4.1.3.4	4.1.4 to 4.1.4.3	4.2	4.2.1	4.2.2	4.2.3 to 4.2.3.4	4.2.4 to 4.2.4.3	4.2.5 to 4.2.5.4	4.3 to 4.3.2	4.4
I-1. Single-speed Compressor; Variable-speed Variable Air Volume Indoor Fan	AC HP		AC HP			HP HH		HP HH				HP	AC HP HH
I-2. Single-speed Compressor Except as Covered by "I-1"		AC HP				HP HH	HP HH					HP	AC HP HH
I-3. Two-capacity Compressor	AC HP			AC HP		HP HH			HP HH			HP	AC HP HH
I-4. Variable-speed Compressor	AC HP				AC HP	HP HH				HP HH		HP	AC HP HH
II-1. Ducted													
II-2. Non-Ducted													
III. Special Features						H					H		
IV. Secondary Test Method													

Legend for Table Entries:

Categories I and II: AC = applies for an Air Conditioner that meets the corresponding Column 1 "Key Equipment . . ." criterion

HP = applies for a Heat Pump that meets the corresponding Column 1 "Key Equipment . . ." criterion

HH = applies for a Heating-only Heat pump that meets the corresponding Column 1 "Key Equipment . . ." criterion

Category III: G = ganged mini-splits or multi-splits;

H = heat pump with a heat comfort controller;

M = units with a multi-speed outdoor fan.

Category IV: O = Outdoor Air Enthalpy Method; C = Compressor Calibration Method; R = Refrigerant Enthalpy Method

2.1 Test room requirements. a. Test using two side-by-side rooms, an indoor test room and an outdoor test room. For multiple-split air conditioners and heat pumps (see Definition 1.30), however, use as many available indoor test rooms as needed to accommodate the total number of indoor units. These rooms must comply with the requirements specified in sections 8.1.2 and 8.1.3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22).

b. Inside these test rooms, use artificial loads during cyclic tests and frost accumulation tests, if needed, to produce stabilized room air temperatures. For one room, select an electric resistance heater(s) having a heating capacity that is approximately equal to the heating capacity of the test unit's condenser. For the second room, select a heater(s) having a capacity that is close to the sensible cooling capacity of the test unit's evaporator. When applied, cycle the heater located in the same room as the test unit evaporator coil ON and OFF when the test unit cycles ON and OFF. Cycle the heater located in the same room as the test unit condensing coil ON and OFF when the test unit cycles OFF and ON.

2.2 Test unit installation requirements. a. Install the unit according to section 8.2 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22). With respect to interconnecting tubing used when testing split systems, however, follow the requirements given in section 6.1.3.5 of ARI Standard 210/240–2006 (incorporated by reference, see § 430.22). When testing triple-split systems (see Definition 1.44), use the tubing length specified in section 6.1.3.5 of ARI Standard 210/240–2006 (incorporated by reference, see § 430.22) to connect the outdoor coil, indoor compressor section, and indoor coil while still meeting the requirement of exposing 10 feet of the tubing to outside conditions. When testing split systems having multiple indoor coils, connect each indoor fan-coil to the outdoor unit using: (a) 25 feet of tubing, or (b) tubing furnished by the manufacturer, whichever is longer. If they are needed to make a secondary measurement of capacity, install refrigerant pressure measuring instruments as described in section 8.2.5 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22). Refer to section 2.10 of this appendix to learn which secondary methods require refrigerant pressure measurements. At a minimum, insulate the low-pressure line(s) of a split-system with insulation having an inside diameter that matches the refrigerant tubing and a nominal thickness of 0.5 inch.

b. For units designed for both horizontal and vertical installation or for both up-flow and down-flow vertical installations, the manufacturer must specify the orientation used for testing. Conduct testing with the following installed:

(1) the most restrictive filter(s);

(2) supplementary heating coils; and

(3) other equipment specified as part of the unit, including all hardware used by a heat comfort controller if so equipped (see Definition 1.28). For small-duct, high-velocity systems, configure all balance dampers or restrictor devices on or inside the unit to fully open or lowest restriction.

c. Testing a ducted unit without having an indoor air filter installed is permissible as long as the minimum external static pressure requirement is adjusted as stated in Table 2, note 3 (see section 3.1.4). Except as noted in section 3.1.9, prevent the indoor air supplementary heating coils from operating during all tests. For coil-only indoor units that are supplied without an enclosure, create an enclosure using 1 inch fiberglass ductboard having a nominal density of 6 pounds per cubic foot. Or alternatively, use some other insulating material having a thermal resistance (''R'' value) between 4 and 6 $hr \cdot ft^2 \cdot {}^\circ F/Btu$. For units where the coil is housed within an enclosure or cabinet, no extra insulating or sealing is allowed.

2.2.1 Defrost control settings. Set heat pump defrost controls at the normal settings which most typify those encountered in generalized climatic region IV. (Refer to Figure 2 and Table 17 of section 4.2 for information on region IV.) For heat pumps that use a time-adaptive defrost control system (see Definition 1.42), the manufacturer must specify the frosting interval to be used during Frost Accumulation tests and provide the procedure for manually initiating the defrost at the specified time. To ease testing of any unit, the manufacturer should provide information and any necessary hardware to manually initiate a defrost cycle.

2.2.2 Special requirements for units having a multiple-speed outdoor fan. Configure the multiple-speed outdoor fan according to the manufacturer's specifications, and thereafter, leave it unchanged for all tests. The controls of the unit must regulate the operation of the outdoor fan during all lab tests except dry coil cooling mode tests. For dry coil cooling mode tests, the outdoor fan must operate at the same speed used during the required wet coil test conducted at the same outdoor test conditions.

2.2.3 Special requirements for multi-split air conditioners and heat pumps, and systems composed of multiple mini-split units (outdoor units located side-by-side) that would normally operate using two or more indoor thermostats. For any test where the system is operated at part load (i.e., one or more compressors ''off'', operating at the intermediate or minimum compressor speed, or at low compressor capacity), the manufacturer shall designate the particular indoor coils that are turned off during the test. For variable-speed systems, the manufacturer must designate at least one indoor unit that is turned off for all tests conducted at minimum compressor speed. For all other part-load tests, the manufacturer shall choose to turn off zero, one, two, or more indoor units. The chosen configuration shall remain unchanged for all tests conducted at the same compressor speed/capacity. For any indoor coil that is turned off during a test, take steps to cease forced airflow through this indoor coil and block its outlet duct. Because these types of systems will have more than one indoor fan and possibly multiple outdoor fans and compressor systems, references in this test procedure to a single indoor fan, outdoor fan, and compressor means all indoor fans, all outdoor fans, and all compressor systems that are turned on during the test.

2.2.4 Wet-bulb temperature requirements for the air entering the indoor and outdoor coils.

2.2.4.1 Cooling mode tests. For wet-coil cooling mode tests, regulate the water vapor content of the air entering the indoor unit to the applicable wet-bulb temperature listed in Tables 3 to 6. As noted in these same tables, achieve a wet-bulb temperature during dry-coil cooling mode tests that results in no condensate forming on the indoor coil. Controlling the water vapor content of the air entering the outdoor side of the unit is not required for cooling mode tests except when testing:

(1) Units that reject condensate to the outdoor coil during wet coil tests. Tables 3–6 list the applicable wet-bulb temperatures.

(2) Single-packaged units where all or part of the indoor section is located in the outdoor test room. The average dew point temperature of the air entering the outdoor coil during wet coil tests must be within ±3.0 °F of the average dew point temperature of the air entering the indoor coil over the 30-minute data collection interval described in section 3.3. For dry coil tests on such units, it may be necessary to limit the moisture content of the air entering the outdoor side of the unit to meet the requirements of section 3.4.

2.2.4.2 Heating mode tests. For heating mode tests, regulate the water vapor content of the air entering the outdoor unit to the applicable wet-bulb temperature listed in Tables 9 to 12. The wet-bulb temperature entering the indoor side of the heat pump must not exceed 60 °F. Additionally, if the Outdoor Air Enthalpy test method is used while testing a single-packaged heat pump where all or part of the outdoor section is located in the indoor test room, adjust the wet-bulb temperature for the air entering the indoor side to yield an indoor-side dew point temperature that is as close as reasonably possible to the dew point temperature of the outdoor-side entering air.

2.2.5 Additional refrigerant charging requirements. Charging according to the ''manufacturer's published instructions,'' as stated in section 8.2 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22), means the manufacturer's installation instructions that come packaged with the unit.If a unit requires charging but the installation instructions do not specify a charging procedure, then evacuate the unit and add the nameplate refrigerant charge. Where the manufacturer's installation instructions contain two sets of refrigerant charging criteria, one for field installations and one for lab testing, use the field installation criteria. For third-party testing, the test laboratory may consult with the manufacturer about the refrigerant charging procedure and make any needed corrections so long as they do not contradict the published installation instructions. The manufacturer may specify an alternative charging criteria to the third-party laboratory so long as the manufacturer thereafter revises the published installation instructions accordingly.

2.3 Indoor air volume rates. If a unit's controls allow for overspeeding the indoor fan (usually on a temporary basis), take the necessary steps to prevent overspeeding during all tests.

2.3.1 Cooling tests. a. Set indoor fan control options (*e.g.*, fan motor pin settings, fan motor speed) according to the published installation instructions that are provided with the equipment while meeting the airflow requirements that are specified in sections 3.1.4.1 to 3.1.4.3.

b. Express the Cooling Full-load Air Volume Rate, the Cooling Minimum Air Volume Rate, and the Cooling Intermediate Air Volume Rate in terms of standard air.

2.3.2 Heating tests. a. If needed, set the indoor fan control options (*e.g.*, fan motor pin settings, fan motor speed) according to the published installation instructions that are provided with the equipment. Do this set-up while meeting all applicable airflow requirements specified in sections 3.1.4.4 to 3.1.4.7.

b. Express the Heating Certified Air Volume Rate, the Heating Minimum Air Volume Rate, the Heating Intermediate Air Volume Rate, and the Heating Nominal Air Volume Rate in terms of standard air.

2.4 Indoor coil inlet and outlet duct connections. Insulate and/or construct the outlet plenum described in section 2.4.1 and, if installed, the inlet plenum described in section 2.4.2 with thermal insulation having a nominal overall sistance (R-value) of at least 19 hr·ft^2· °F/Btu.

2.4.1 Outlet plenum for the indoor unit. a. Attach a plenum to the outlet of the indoor coil. (NOTE: for some packaged systems, the indoor coil may be located in the outdoor test room.)

b. For systems having multiple indoor coils, attach a plenum to each indoor coil outlet. Connect two or more outlet plenums to a single common duct so that each indoor coil ultimately connects to an airflow measuring apparatus (section 2.6). If using more than one indoor test room, do likewise, creating one or more common ducts within each test room that contains multiple indoor coils. At the plane where each plenum enters a common duct, install an adjustable airflow damper and use it to equalize the static pressure in each plenum. Each outlet air temperature grid (section 2.5.4) and airflow measuring apparatus are located downstream of the inlet(s) to the common duct.

c. For small-duct, high-velocity systems, install an outlet plenum that has a diameter that is equal to or less than the value listed below. The limit depends only on the cooling Full-Load Air Volume Rate (see section 3.1.4.1.1) and is effective regardless of the flange dimensions on the outlet of the unit (or an air supply plenum adapter accessory, if installed in accordance with the manufacturer's installation instructions).

d. Add a static pressure tap to each face of the (each) outlet plenum, if rectangular, or at four evenly distributed locations along the circumference of an oval or round plenum. Create a manifold that connects the four static pressure taps. Figure 1 shows two of the three options allowed for the manifold configuration; the third option is the broken-ring, four-to-one manifold configuration that is shown in Figure 7a of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22). See Figures 7a, 7b, 7c, and 8 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22) for the cross-sectional dimensions and minimum length of the (each) plenum and the locations for adding the static pressure taps for units tested with and without an indoor fan installed.

Cooling full-load air volume rate (scfm)	Maximum diameter* of outlet plenum (inches)
≤500	6
501 to 700	7
701 to 900	8
901 to 1100	9
1101 to 1400	10
1401 to 1750	11

*If the outlet plenum is rectangular, calculate its equivalent diameter using ($4A/P$,) where A is the area and P is the perimeter of the rectangular plenum, and compare it to the listed maximum diameter.

2.4.2 Inlet plenum for the indoor unit. Install an inlet plenum when testing a coil-only indoor unit or a packaged system where the indoor coil is located in the outdoor test room. Add static pressure taps at the center of each face of this plenum, if rectangular, or at four evenly distributed locations along the circumference of an oval or round plenum. Make a manifold that connects the four static-pressure taps using one of the three configurations specified in section 2.4.1. See Figures 7b, 7c, and Figure 8 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22) for cross-sectional dimensions, the minimum length of the inlet plenum, and the locations of the static-pressure taps. When testing a ducted unit having an indoor fan (and the indoor coil is in the indoor test room), the manufacturer has the option to test with or without an inlet plenum installed. Space limitations within the test room may dictate that the manufacturer choose the latter option. If used, construct the inlet plenum and add the four static-pressure taps as shown in Figure 8 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22). Manifold the four static-pressure taps using one of the three configurations specified in section 2.4.1. Never use an inlet plenum when testing a non-ducted system.

2.5 Indoor coil air property measurements and air damper box applications. a. Measure the dry-bulb temperature and water vapor content of the air entering and leaving the indoor coil. If needed, use an air sampling device to divert air to a sensor(s) that measures the water vapor content of the air. See Figure 2 of ASHRAE Standard 41.1–86 (RA 01) (incorporated by reference, see §430.22) for guidance on constructing an air sampling device. The sampling device may also divert air to a remotely located sensor(s) that measures dry bulb temperature. The air sampling device and the remotely located temperature sensor(s) may be used to determine the entering air dry bulb temperature during any test. The air sampling device and the remotely located leaving air dry bulb temperature sensor(s) may be used for all tests except:

(1) Cyclic tests; and

(2) Frost accumulation tests.

b. An acceptable alternative in all cases, including the two special cases noted above, is to install a grid of dry bulb temperature sensors within the outlet and inlet ducts. Use a temperature grid to get the average dry bulb temperature at one location, leaving or entering, or when two grids are applied as a thermopile, to directly obtain the temperature difference. A grid of temperature sensors (which may also be used for determining average leaving air dry bulb temperature) is required to measure the temperature distribution within a cross-section of the leaving airstream.

c. Use an inlet and outlet air damper box when testing ducted systems if conducting one or both of the cyclic tests listed in sections 3.2 and 3.6. Otherwise, install an outlet air damper box when testing heat pumps, both ducted and non-ducted, that cycle off the indoor fan during defrost cycles if no other means is available for preventing natural or forced convection through the indoor unit when the indoor fan is off. Never use an inlet damper box when testing a non-ducted system.

2.5.1 Test set-up on the inlet side of the indoor coil: for cases where the inlet damper box is installed. a. Install the inlet side damper box as specified in section 2.5.1.1 or 2.5.1.2, whichever applies. Insulate or construct the ductwork between the point where the air damper is installed and where the connection is made to either the inlet plenum (section 2.5.1.1 units) or the indoor unit (section 2.5.1.2 units) with thermal insulation that has a nominal overall resistance (R-value) of at least 19 hr·ft^2· °F/Btu.

b. Locate the grid of entering air dry-bulb temperature sensors, if used, at the inlet of the damper box. Locate the air sampling device, or the sensor used to measure the water vapor content of the inlet air, at a location immediately upstream of the damper box inlet.

2.5.1.1 If the section 2.4.2 inlet plenum is installed. Install the inlet damper box upstream of the inlet plenum. The cross-sectional flow area of the damper box must be equal to or greater than the flow area of the inlet plenum. If needed, use an adaptor plate or a transition duct section to connect the damper box with the inlet plenum.

2.5.1.2 If the section 2.4.2 inlet plenum is not installed. Install the damper box immediately upstream of the air inlet of the indoor unit. The cross-sectional dimensions of the damper box must be equal to or greater than the dimensions of the indoor unit inlet. If needed, use an adaptor plate or a short transition duct section to connect the damper box with the unit's air inlet. Add static pressure taps at the center of each face of the damper box, if rectangular, or at four evenly distributed locations along the circumference, if oval or round. Locate the pressure taps between the inlet damper and the inlet of the indoor unit. Make a manifold that connects the four static pressure taps.

2.5.2 Test set-up on the inlet side of the indoor unit: for cases where no inlet damper box is installed. If using the section 2.4.2 inlet plenum and a grid of dry bulb temperature sensors, mount the grid at a location upstream of the static pressure taps described in section 2.4.2, preferably at the entrance plane of the inlet plenum. If the section 2.4.2 inlet plenum is not used, but a grid of dry bulb temperature sensors is used, locate the grid approximately 6 inches upstream from the inlet of the indoor coil. Or, in the case of non-ducted units having multiple indoor coils, locate a grid approximately 6 inches upstream from the inlet of each indoor coil. Position an air sampling device, or the sensor used to measure the water vapor content of the inlet air, immediately upstream of the (each) entering air dry-bulb temperature sensor grid. If a grid of sensors is not used, position the entering air sampling device (or the sensor used to measure the water vapor content of the inlet air) as if the grid were present.

2.5.3 Indoor coil static pressure difference measurement. Section 6.5.2 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22) describes the method for fabricating static-pressure taps. Also refer to Figure 2A of ASHRAE Standard 51–99/AMCA Standard 210–99 (incorporated by reference, see §430.22). Use a differential pressure measuring instrument that is accurate to within ±0.01 inches of water and has a resolution of at least 0.01 inches of water to measure the static pressure difference between the indoor coil air inlet and outlet. Connect one side of the differential pressure instrument to the manifolded pressure taps installed in the outlet plenum. Connect the other side of the instrument to the manifolded pressure taps located in either the inlet plenum or incorporated within the air damper box. If an inlet plenum or inlet damper box are not used, leave the inlet side of the differential pressure instrument open to the surrounding atmosphere. For non-ducted systems that are tested with multiple outlet plenums, measure the static pressure within each outlet plenum relative to the surrounding atmosphere.

2.5.4 Test set-up on the outlet side of the indoor coil. a. Install an interconnecting duct between the outlet plenum described in section 2.4.1 and the airflow measuring apparatus described below in section 2.6. The cross-sectional flow area of the interconnecting duct must be equal to or greater than the flow area of the outlet plenum or the common duct used when testing non-ducted units having multiple indoor coils. If needed, use adaptor plates or transition duct sections to allow the connections. To minimize leakage, tape joints within the interconnecting duct (and the outlet plenum). Construct or insulate the entire flow section with thermal insulation having a nominal overall resistance (R-value) of at least 19 hr·ft^2·°F/Btu.

b. Install a grid(s) of dry-bulb temperature sensors inside the interconnecting duct. Also, install an air sampling device, or the sensor(s) used to measure the water vapor content of the outlet air, inside the interconnecting duct. Locate the dry-bulb temperature grid(s) upstream of the air sampling device (or the in-duct sensor(s) used to measure the water vapor content of the outlet air). Air that circulates through an air sampling device and past a remote water-vapor-content sensor(s) must be returned to the interconnecting duct at a point:

(1) Downstream of the air sampling device;

(2) Upstream of the outlet air damper box, if installed; and

(3) Upstream of the section 2.6 airflow measuring apparatus.

2.5.4.1 Outlet air damper box placement and requirements. If using an outlet air damper box (see section 2.5), install it within the interconnecting duct at a location downstream of the location where air from the sampling device is reintroduced or downstream of the in-duct sensor that measures water vapor content of the outlet air. The leakage rate from the combination of the outlet plenum, the closed damper, and the duct section that connects these two components must not exceed 20 cubic feet per minute when a negative pressure of 1 inch of water column is maintained at the plenum's inlet.

2.5.4.2 Procedures to minimize temperature maldistribution. Use these procedures if necessary to correct temperature maldistributions. Install a mixing device(s) upstream of the outlet air, dry-bulb temperature grid (but downstream of the outlet plenum static pressure taps). Use a perforated screen located between the mixing device and the dry-bulb temperature grid, with a maximum open area of 40 percent. One or both items should help to meet the maximum outlet air temperature distribution specified in section 3.1.8. Mixing devices are described in sections 6.3—6.5 of ASHRAE Standard 41.1–86 (RA 01) (incorporated by reference, see § 430.22) and section 5.2.2 of ASHRAE Standard 41.2–87 (RA 92) (incorporated by reference, see § 430.22).

2.5.4.3 Minimizing air leakage. For small-duct, high-velocity systems, install an air damper near the end of the interconnecting duct, just prior to the transition to the airflow measuring apparatus of section 2.6. To minimize air leakage, adjust this damper such that the pressure in the receiving chamber of the airflow measuring apparatus is no more than 0.5 inch of water higher than the surrounding test room ambient. In lieu of installing a separate damper, use the outlet air damper box of sections 2.5 and 2.5.4.1 if it allows variable positioning. Also apply these steps to any conventional indoor blower unit that creates a static pressure within the receiving chamber of the airflow measuring apparatus that exceeds the test room ambient pressure by more than 0.5 inches of water column.

2.5.5 Dry bulb temperature measurement. a. Measure dry bulb temperatures as specified in sections 4, 5, 6.1–6.10, 9, 10, and 11 of ASHRAE Standard 41.1–86 (RA 01) (incorporated by reference, see § 430.22). The transient testing requirements cited in section 4.3 of ASHRAE Standard 41.1–86 (RA 01) (incorporated by reference, see § 430.22) apply if conducting a cyclic or frost accumulation test.

b. Distribute the sensors of a dry-bulb temperature grid over the entire flow area. The required minimum is 9 sensors per grid.

2.5.6 Water vapor content measurement. Determine water vapor content by measuring dry-bulb temperature combined with the air wet-bulb temperature, dew point temperature, or relative humidity. If used, construct and apply wet-bulb temperature sensors as specified in sections 4, 5, 6, 9, 10, and 11 of ASHRAE Standard 41.1–86 (RA 01) (incorporated by reference, see § 430.22). As specified in ASHRAE 41.1–86 (RA 01) (incorporated by reference, see § 430.22), the temperature sensor (wick removed) must be accurate to within ±0.2 °F. If used, apply dew point hygrometers as specified in sections 5 and 8 of ASHRAE Standard 41.6–94 (RA 01) (incorporated by reference, see § 430.22). The dew point hygrometers must be accurate to within ±0.4 °F when operated at conditions that result in the evaluation of dew points above 35 °F. If used, a relative humidity (RH) meter must be accurate to within ±0.7% RH. Other means to determine the psychrometric state of air may be used as long as the measurement accuracy is equivalent to or better than the accuracy achieved from using a wet-bulb temperature sensor that meets the above specifications.

2.5.7 Air damper box performance requirements. If used (see section 2.5), the air damper box(es) must be capable of being completely opened or completely closed within 10 seconds for each action.

2.6 Airflow measuring apparatus. a. Fabricate and operate an Air Flow Measuring Apparatus as specified in section 6.6 of ASHRAE Standard 116–95 (RA05) (incorporated by reference, see § 430.22). Refer to Figure 12 of ASHRAE Standard 51–99/AMCA Standard 210–99 (incorporated by reference, see § 430.22) or Figure 14 of ASHRAE Standard 41.2–87 (RA 92) (incorporated by reference, see § 430.22) for guidance on placing the static pressure taps and positioning the diffusion baffle (settling means) relative to the chamber inlet.

b. Connect the airflow measuring apparatus to the interconnecting duct section described in section 2.5.4. See sections 6.1.1, 6.1.2, and 6.1.4, and Figures 1, 2, and 4 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22), and Figures D1, D2, and D4 of ARI Standard 210/240–2006 (incorporated by reference, see § 430.22) for illustrative examples of how the test apparatus may be applied within a complete laboratory set-up. Instead of following one of these examples, an alternative set-up may be used to handle the air leaving the airflow measuring apparatus and to supply properly conditioned air to the test unit's inlet. The alternative set-up, however, must not interfere with the prescribed means for measuring airflow rate, inlet and outlet air temperatures, inlet and outlet water vapor contents, and external static pressures, nor create abnormal conditions surrounding the test unit. (Note: Do not use an enclosure as described in section 6.1.3 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22) when testing triple-split units.)

2.7 Electrical voltage supply. Perform all tests at the voltage specified in section 6.1.3.2 of ARI Standard 210/240–2006 (incorporated by reference, see § 430.22) for ''Standard Rating Tests.'' Measure the supply voltage at the terminals on the test unit using a volt meter that provides a reading that is accurate to within ±1.0 percent of the measured quantity.

2.8 Electrical power and energy measurements. a. Use an integrating power (watt-hour) measuring system to determine the electrical energy or average electrical power supplied to all components of the air conditioner or heat pump (including auxiliary components such as controls, transformers, crankcase heater, integral condensate pump on non-ducted indoor units, etc.). The watt-hour measuring system must give readings that are accurate to within ±0.5 percent. For cyclic tests, this accuracy is required during both the ON and OFF cycles. Use either two different scales on the same watt-hour meter or two separate watt-hour meters. Activate the scale or meter having the lower power rating within 15 seconds after beginning an

OFF cycle. Activate the scale or meter having the higher power rating active within 15 seconds prior to beginning an ON cycle. For ducted units tested with a fan installed, the ON cycle lasts from compressor ON to indoor fan OFF. For ducted units tested without an indoor fan installed, the ON cycle lasts from compressor ON to compressor OFF. For non-ducted units, the ON cycle lasts from indoor fan ON to indoor fan OFF. When testing air conditioners and heat pumps having a variable-speed compressor, avoid using an induction watt/watt-hour meter.

b. When performing section 3.5 and/or 3.8 cyclic tests on non-ducted units, provide instrumentation to determine the average electrical power consumption of the indoor fan motor to within ±1.0 percent. If required according to sections 3.3, 3.4, 3.7, 3.9.1, and/or 3.10, this same instrumentation requirement applies when testing air conditioners and heat pumps having a variable-speed constant-air-volume-rate indoor fan or a variable-speed, variable-air-volume-rate indoor fan.

2.9 Time measurements. Make elapsed time measurements using an instrument that yields readings accurate to within ±0.2 percent.

2.10 Test apparatus for the secondary space conditioning capacity measurement. For all tests, use the Indoor Air Enthalpy Method to measure the unit's capacity. This method uses the test set-up specified in sections 2.4 to 2.6. In addition, for all steady-state tests, conduct a second, independent measurement of capacity as described in section 3.1.1. For split systems, use one of the following secondary measurement methods: Outdoor Air Enthalpy Method, Compressor Calibration Method, or Refrigerant Enthalpy Method. For single packaged units, use either the Outdoor Air Enthalpy Method or the Compressor Calibration Method as the secondary measurement.

2.10.1 Outdoor Air Enthalpy Method. a. To make a secondary measurement of indoor space conditioning capacity using the Outdoor Air Enthalpy Method, do the following:

(1) Measure the electrical power consumption of the test unit;

(2) Measure the air-side capacity at the outdoor coil; and

(3) Apply a heat balance on the refrigerant cycle.

b. The test apparatus required for the Outdoor Air Enthalpy Method is a subset of the apparatus used for the Indoor Air Enthalpy Method. Required apparatus includes the following:

(1) An outlet plenum containing static pressure taps (sections 2.4, 2.4.1, and 2.5.3),

(2) An airflow measuring apparatus (section 2.6),

(3) A duct section that connects these two components and itself contains the instrumentation for measuring the dry-bulb temperature and water vapor content of the air leaving the outdoor coil (sections 2.5.4, 2.5.5, and 2.5.6), and

(4) On the inlet side, a sampling device and optional temperature grid (sections 2.5 and 2.5.2).

c. During the preliminary tests described in sections 3.11.1 and 3.11.1.1, measure the evaporator and condenser temperatures or pressures. On both the outdoor coil and the indoor coil, solder a thermocouple onto a return bend located at or near the midpoint of each coil or at points not affected by vapor superheat or liquid subcooling. Alternatively, if the test unit is not sensitive to the refrigerant charge, connect pressure gages to the access valves or to ports created from tapping into the suction and discharge lines. Use this alternative approach when testing a unit charged with a zeotropic refrigerant having a temperature glide in excess of 1 °F at the specified test conditions.

2.10.2 Compressor Calibration Method. Measure refrigerant pressures and temperatures to determine the evaporator superheat and the enthalpy of the refrigerant that enters and exits the indoor coil. Determine refrigerant flow rate or, when the superheat of the refrigerant leaving the evaporator is less than 5 °F, total capacity from separate calibration tests conducted under identical operating conditions. When using this method, install instrumentation, measure refrigerant properties, and adjust the refrigerant charge according to section 7.4.2 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22). Use refrigerant temperature and pressure measuring instruments that meet the specifications given in sections 5.1.1 and 5.2 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22).

2.10.3 Refrigerant Enthalpy Method. For this method, calculate space conditioning capacity by determining the refrigerant enthalpy change for the indoor coil and directly measuring the refrigerant flow rate. Use section 7.5.2 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22) for the requirements for this method, including the additional instrumentation requirements, and information on placing the flow meter and a sight glass. Use refrigerant temperature, pressure, and flow measuring instruments that meet the specifications given in sections 5.1.1, 5.2, and 5.5.1 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22).

2.11 Measurement of test room ambient conditions. a. If using a test set-up where air is ducted directly from the conditioning apparatus to the indoor coil inlet (see Figure 2, Loop Air-Enthalpy Test Method Arrangement, of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22)), add instrumentation to permit measurement of the indoor test room dry-bulb temperature.

b. If the Outdoor Air Enthalpy Method is not used, add instrumentation to measure the dry-bulb temperature and the water vapor content of the air entering the outdoor coil. If an air sampling device is used, construct and apply the device as per section 6 of ASHRAE Standard 41.1–86 (RA 01) (incorporated by reference, see §430.22). Take steps (*e.g.*, add or re-position a lab circulating fan), as needed, to minimize the magnitude of the temperature distribution non-uniformity. Position any fan in the outdoor test room while trying to keep air velocities in the vicinity of the test unit below 500 feet per minute.

c. Measure dry bulb temperatures as specified in sections 4, 5, 6.1–6.10, 9, 10, and 11 of ASHRAE Standard 41.1–86 (RA 01) (incorporated by reference, see §430.22). Measure water vapor content as stated above in section 2.5.6.

2.12 Measurement of indoor fan speed. When required, measure fan speed using a revolution counter, tachometer, or stroboscope that gives readings accurate to within ±1.0 percent.

2.13 Measurement of barometric pressure. Determine the average barometric pressure during each test. Use an instrument that meets the requirements specified in section 5.2 of ASHRAE Standard 37–2005(incorporated by reference, see §430.22).

3. Testing Procedures

3.1 General Requirements. If, during the testing process, an equipment set-up adjustment is made that would alter the performance of the unit when conducting an already completed test, then repeat all tests affected by the adjustment. For cyclic tests, instead of maintaining an air volume rate, for each airflow nozzle, maintain the static pressure difference or velocity pressure during an ON period at the same pressure difference or velocity pressure as measured during the steady-state test conducted at the same test conditions.

3.1.1 Primary and secondary test methods. For all tests, use the Indoor Air Enthalpy Method test apparatus to determine the unit's space conditioning capacity. The procedure and data collected, however, differ slightly depending upon whether the test is a steady-state test, a cyclic test, or a frost accumulation test. The following sections described these differences. For all steady-state tests (*i.e.*, the A, A_2, A_1, B, B_2, B_1, C, C_1, EV, F_1, G_1, $H0_1$, H_1, $H1_2$, $H1_1$, HI_N, H_3, $H3_2$, and $H3_1$ Tests), in addition, use one of the acceptable secondary methods specified in section 2.10 to determine indoor space conditioning capacity. Calculate this secondary check of capacity according to section 3.11. The two capacity measurements must agree to within 6 percent to constitute a valid test. For this capacity comparison, use the Indoor Air Enthalpy Method capacity that is calculated in section 7.3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22) (and, if testing a coil-only unit, do not make the after-test fan heat adjustments described in section 3.3, 3.4, 3.7, and 3.10 of this appendix). However, include the appropriate section 3.3 to 3.5 and 3.7 to 3.10 fan heat adjustments within the Indoor Air Enthalpy Method capacities used for the section 4 seasonal calculations.

3.1.2 Manufacturer-provided equipment overrides. Where needed, the manufacturer must provide a means for overriding the controls of the test unit so that the compressor(s) operates at the specified speed or capacity and the indoor fan operates at the specified speed or delivers the specified air volume rate.

3.1.3 Airflow through the outdoor coil. For all tests, meet the requirements given in section 6.1.3.4 of ARI Standard 210/240–2006(incorporated by reference, see §430.22) when obtaining the airflow through the outdoor coil.

3.1.4 Airflow through the indoor coil.

3.1.4.1 Cooling Full-load Air Volume Rate.

3.1.4.1.1 Cooling Full-Load Air Volume Rate for Ducted Units. The manufacturer must specify the Cooling Full-load Air Volume Rate. Use this value as long as the following two requirements are satisfied. First, when conducting the A or A_2 Test (exclusively), the measured air volume rate, when divided by the measured indoor air-side total cooling capacity must not exceed 37.5 cubic feet per minute of standard air (scfm) per 1000 Btu/h. If this ratio is exceeded, reduce the air volume rate until this ratio is equaled. Use this reduced air volume rate for all tests that call for using the Cooling Full-load Air Volume Rate. The second requirement is as follows:

a. For all ducted units tested with an indoor fan installed, except those having a variable-speed, constant-air-volume-rate indoor fan. The second requirement applies exclusively to the A or A_2 Test and is met as follows.

1. Achieve the Cooling Full-load Air Volume Rate, determined in accordance with the previous paragraph;

2. Measure the external static pressure;

3. If this pressure is equal to or greater than the applicable minimum external static pressure cited in Table 2, this second requirement is satisfied. Use the current air volume rate for all tests that require the Cooling Full-load Air Volume Rate.

4. If the Table 2 minimum is not equaled or exceeded,

4a. reduce the air volume rate until the applicable Table 2 minimum is equaled or

4b. until the measured air volume rate equals 95 percent of the air volume rate from step 1, whichever occurs first.

5. If the conditions of step 4a occur first, this second requirement is satisfied. Use the

step 4a reduced air volume rate for all tests that require the Cooling Full-load Air Volume Rate.

6. If the conditions of step 4b occur first, make an incremental change to the set-up of the indoor fan (e.g., next highest fan motor pin setting, next highest fan motor speed) and repeat the evaluation process beginning at above step 1. If the indoor fan set-up cannot be further changed, reduce the air volume rate until the applicable Table 2 minimum is equaled. Use this reduced air volume rate for all tests that require the Cooling Full-load Air Volume Rate.

b. For ducted units that are tested with a variable-speed, constant-air-volume-rate indoor fan installed.For all tests that specify the Cooling Full-load Air Volume Rate, obtain an external static pressure as close to (but not less than) the applicable Table 2 value that does not cause instability or an automatic shutdown of the indoor blower.

c. For ducted units that are tested without an indoor fan installed. For the A or A_2 Test, (exclusively), the pressure drop across the indoor coil assembly must not exceed 0.30 inches of water. If this pressure drop is exceeded, reduce the air volume rate until the measured pressure drop equals the specified maximum. Use this reduced air volume rate for all tests that require the Cooling Full-loadAir Volume Rate.

TABLE 2—MINIMUM EXTERNAL STATIC PRESSURE FOR DUCTED SYSTEMS TESTED WITH AN INDOOR FAN INSTALLED

Rated Cooling [1] or Heating [2] Capacity (Btu/h)	Minimum external resistance [3] (Inches of water)	
	All other systems	Small-duct, high-velocity systems [4,5]
Up Thru 28,800	0.10	1.10
29,000 to 42,500	0.15	1.15
43,000 and Above	0.20	1.20

[1] For air conditioners and heat pumps, the value cited by the manufacturer in published literature for the unit's capacity when operated at the *A* or *A_2* Test conditions.

[2] For heating-only heat pumps, the value the manufacturer cites in published literature for the unit's capacity when operated at the *H1* or *$H1_2$* Test conditions.

[3] For ducted units tested without an air filter installed, increase the applicable tabular value by 0.08 inch of water.

[4] See Definition 1.35 to determine if the equipment qualifies as a small-duct, high-velocity system.

[5] If a closed-loop, air-enthalpy test apparatus is used on the indoor side, limit the resistance to airflow on the inlet side of the indoor blower coil to a maximum value of 0.1 inch of water. Impose the balance of the airflow resistance on the outlet side of the indoor blower.

3.1.4.1.2 Cooling Full-load Air Volume Rate for Non-ducted Units. For non-ducted units, the Cooling Full-load Air Volume Rate is the air volume rate that results during each test when the unit is operated at an external static pressure of zero inches of water.

3.1.4.2 Cooling Minimum Air Volume Rate. a. For ducted units that regulate the speed (as opposed to the cfm) of the indoor fan,

$$\text{Cooling Minimum Air Vol. Rate} = \text{Cooling Full-load Air Vol. Rate} \times \frac{\text{Cooling Minimum Fan Speed}}{\text{A}_2\text{Test Fan Speed}},$$

where ''Cooling Minimum Fan Speed'' corresponds to the fan speed used when operating at low compressor capacity (two-capacity system), the fan speed used when operating at the minimum compressor speed (variable-speed system), or the lowest fan speed used when cooling (single-speed compressor and a variable-speed variable-air-volume-rate indoor fan). For such systems, obtain the Cooling Minimum Air Volume Rate regardless of the external static pressure.

b. For ducted units that regulate the air volume rate provided by the indoor fan, the manufacturer must specify the Cooling Minimum Air Volume Rate. For such systems, conduct all tests that specify the Cooling Minimum Air Volume Rate—(*i.e.*, the A_1, B_1, C_1, F_1, and G_1 Tests)—at an external static pressure that does not cause instability or an automatic shutdown of the indoor blower while being as close to, but not less than,

$$A_1,\ B_1,\ C_1,\ F_1,\ \&\ G_1\ \text{Test}\ \Delta P_{st} = \Delta P_{st,\,A_2} \times \left[\frac{\text{Cooling Minimum Air Volume Rate}}{\text{Cooling Full-load Air Volume Rate}}\right]^2,$$

where $\Delta P_{st,A_2}$ is the applicable Table 2 minimum external static pressure that was targeted during the A_2 (and B_2) Test.

c. For ducted two-capacity units that are tested without an indoor fan installed, the Cooling Minimum Air Volume Rate is the higher of (1) the rate specified by the manufacturer or (2) 75 percent of the Cooling Full-load Air Volume Rate. During the laboratory tests on a coil-only (fanless) unit, obtain this Cooling Minimum Air Volume Rate regardless of the pressure drop across the indoor coil assembly.

d. For non-ducted units, the Cooling Minimum Air Volume Rate is the air volume rate that results during each test when the unit operates at an external static pressure of zero inches of water and at the indoor fan setting used at low compressor capacity (two-capacity system) or minimum compressor speed (variable-speed system). For units having a single-speed compressor and a variable-speed variable-air-volume-rate indoor fan, use the lowest fan setting allowed for cooling.

3.1.4.3 Cooling Intermediate Air Volume Rate. a. For ducted units that regulate the speed of the indoor fan,

$$\text{Cooling Intermediate Air Vol. Rate} = \text{Cooling Full-load Air Vol. Rate} \times \frac{E_V \text{Test Fan Speed}}{A_2 \text{Test Fan Speed}},$$

For such units, obtain the Cooling Intermediate Air Volume Rate regardless of the external static pressure.

b. For ducted units that regulate the air volume rate provided by the indoor fan, the manufacturer must specify the Cooling Intermediate Air Volume Rate. For such systems, conduct the E_V Test at an external static pressure that does not cause instability or an automatic shutdown of the indoor blower while being as close to, but not less than,

$$E_V \text{Test } \Delta P_{st} = \Delta P_{st,\ A_2} \times \left[\frac{\text{Cooling Intermediate Air Volume Rate}}{\text{Cooling Full-load Air Volume Rate}}\right]^2,$$

where $\Delta P_{st,A_2}$ is the applicable Table 2 minimum external static pressure that was targeted during the A_2 (and B_2) Test.

c. For non-ducted units, the Cooling Intermediate Air Volume Rate is the air volume rate that results when the unit operates at an external static pressure of zero inches of water and at the fan speed selected by the controls of the unit for the E_V Test conditions.

3.1.4.4 Heating Full-load Air Volume Rate.

3.1.4.4.1 Ducted heat pumps where the Heating and Cooling Full-load Air Volume Rates are the same. a. Use the Cooling Full-load Air Volume Rate as the Heating Full-loadAir Volume Rate for:

1. Ducted heat pumps that operate at the same indoor fan speed during both the A (or A_2) and the H1 (or $H1_2$) Tests;

2. Ducted heat pumps that regulate fan speed to deliver the same constant air volume rate during both the A (or A_2) and the H1 (or $H1_2$) Tests; and

3. Ducted heat pumps that are tested without an indoor fan installed (except two-capacity northern heat pumps that are tested only at low capacity cooling—see 3.1.4.4.2).

b. For heat pumps that meet the above criteria ''1'' and ''3,'' no minimum requirements apply to the measured external or internal, respectively, static pressure. For heat pumps that meet the above criterion ''2,'' test at an external static pressure that does not cause instability or an automatic shutdown of the indoor blower while being as close to, but not less than, the same Table 2 minimum external static pressure as was specified for the A (or A_2) cooling mode test.

3.1.4.4.2 Ducted heat pumps where the Heating and Cooling Full-loadAir Volume Rates are different due to indoor fan operation. a. For ducted heat pumps that regulate the speed (as opposed to the cfm) of the indoor fan,

$$\text{Heating Full-load Air Volume Rate} = \text{Cooling Full-load Air Volume Rate} \times \frac{\text{H1 or H1}_2 \text{ Test Fan Speed}}{\text{A or A}_2 \text{ Test Fan Speed}},$$

For such heat pumps, obtain the Heating Full-loadAir Volume Rate without regard to the external static pressure.

b. For ducted heat pumps that regulate the air volume rate delivered by the indoor fan, the manufacturer must specify the Heating Full-load Air Volume Rate. For such heat pumps, conduct all tests that specify the Heating Full-load Air Volume Rate at an external static pressure that does not cause instability or an automatic shutdown of the indoor blower while being as close to, but not less than,

$$\text{Heating Full-load } \Delta P_{st} = \text{Cooling Full-load } \Delta P_{st} \times \left[\frac{\text{Heating Full-load Air Volume Rate}}{\text{Cooling Full-load Air Volume Rate}}\right]^2,$$

where the Cooling Certified ΔP_{st} is the applicable Table 2 minimum external static pressure that was specified for the A or A_2 Test.

c. When testing ducted, two-capacity northern heat pumps (see Definition 1.46), use the appropriate approach of the above two cases for units that are tested with an indoor fan installed. For coil-only (fanless) northern heat pumps, the Heating Full-load Air Volume Rate is the lesser of the rate specified by the manufacturer or 133 percent of the Cooling Full-load Air Volume Rate. For this latter case, obtain the Heating Full-load Air Volume Rate regardless of the pressure drop across the indoor coil assembly.

3.1.4.4.3 Ducted heating-only heat pumps. The manufacturer must specify the Heating Full-load Air Volume Rate.

a. For all ducted heating-only heat pumps tested with an indoor fan installed, except those having a variable-speed, constant-air-volume-rate indoor fan. Conduct the following steps only during the first test, the H1 or $H1_2$ Test.

1. Achieve the Heating Full-load Air Volume Rate.

2. Measure the external static pressure.

3. If this pressure is equal to or greater than the Table 2 minimum external static pressure that applies given the heating-only heat pump's rated heating capacity, use the current air volume rate for all tests that require the Heating Full-load Air Volume Rate.

4. If the Table 2 minimum is not equaled or exceeded,

4a. reduce the air volume rate until the applicable Table 2 minimum is equaled or

4b. until the measured air volume rate equals 95 percent of the manufacturer-specified Full-load Air Volume Rate, whichever occurs first.

5. If the conditions of step 4a occurs first, use the step 4a reduced air volume rate for all tests that require the Heating Full-load Air Volume Rate.

6. If the conditions of step 4b occur first, make an incremental change to the set-up of the indoor fan (e.g., next highest fan motor pin setting, next highest fan motor speed) and repeat the evaluation process beginning at above step 1. If the indoor fan set-up cannot be further changed, reduce the air volume rate until the applicable Table 2 minimum is equaled. Use this reduced air volume rate for all tests that require the Heating Full-load Air Volume Rate.

b.For ducted heating-only heat pumps that are tested with a variable-speed, constant-air-volume-rate indoor fan installed. For all tests that specify the Heating Full-load Air Volume Rate, obtain an external static pressure that does not cause instability or an automatic shutdown of the indoor blower while being as close to, but not less than, the applicable Table 2 minimum.

c. For ducted heating-only heat pumps that are tested without an indoor fan installed. For the H1 or $H1_2$ Test, (exclusively), the pressure drop across the indoor coil assembly must not exceed 0.30 inches of water. If this pressure drop is exceeded, reduce the air volume rate until the measured pressure drop equals the specified maximum. Use this reduced air volume rate for all tests that require the Heating Full-load Air Volume Rate.

3.1.4.4.4 Non-ducted heat pumps, including non-ducted heating-only heat pumps. For non-ducted heat pumps, the Heating Full-loadAir Volume Rate is the air volume rate that results during each test when the unit operates at an external static pressure of zero inches of water.

3.1.4.5 Heating Minimum Air Volume Rate. a. For ducted heat pumps that regulate the speed (as opposed to the cfm) of the indoor fan,

$$\text{Heating Minimum Air Vol. Rate} = \text{Heating Full-load Air Vol. Rate} \times \frac{\text{Heating Minimum Fan Speed}}{\text{H1}_2\text{Test Fan Speed}},$$

where ‘‘Heating Minimum Fan Speed’’ corresponds to the fan speed used when operating at low compressor capacity (two-capacity system), the lowest fan speed used at any time when operating at the minimum compressor speed (variable-speed system), or the lowest fan speed used when heating (single-speed compressor and a variable-speed variable-air-volume-rate indoor fan). For such heat pumps, obtain the Heating Minimum Air Volume Rate without regard to the external static pressure.

b. For ducted heat pumps that regulate the air volume rate delivered by the indoor fan, the manufacturer must specify the Heating Minimum Air Volume Rate. For such heat pumps, conduct all tests that specify the Heating Minimum Air Volume Rate—(*i.e.*, the $H0_1$, $H1_1$, $H2_1$, and $H3_1$ Tests)—at an external static pressure that does not cause instability or an automatic shutdown of the indoor blower while being as close to, but not less than,

$$H0_1,\ H1_1,\ H2_1,\ H3_1,\ \text{Test}\ \Delta P_{st} = \Delta P_{st,\,H1_2} \times \left[\frac{\text{Htg Minimum Air Vol. Rate}}{\text{Htg Full-load Air Vol. Rate}}\right]^2,$$

where $\Delta P_{st,H1_2}$

is the minimum external static pressure that was targeted during the $H1_2$ Test.

c. For ducted two-capacity northern heat pumps that are tested with an indoor fan installed, use the appropriate approach of the above two cases.

d. For ducted two-capacity heat pumps that are tested without an indoor fan installed, use the Cooling Minimum Air Volume Rate as the Heating Minimum Air Volume Rate. For ducted two-capacity northern heat pumps that are tested without an indoor fan installed, use the Cooling Full-load Air Volume Rate as the Heating Minimum Air Volume Rate. For ducted two-capacity heating-only heat pumps that are tested without an indoor fan installed, the Heating Minimum Air Volume Rate is the higher of the rate specified by the manufacturer or 75 percent of the Heating Full-load Air Volume Rate. During the laboratory tests on a coil-only (fanless) unit, obtain the Heating Minimum Air Volume Rate without regard to the pressure drop across the indoor coil assembly.

e. For non-ducted heat pumps, the Heating Minimum Air Volume Rate is the air volume rate that results during each test when the unit operates at an external static pressure of zero inches of water and at the indoor fan setting used at low compressor capacity (two-capacity system) or minimum compressor speed (variable-speed system). For units having a single-speed compressor and a variable-speed, variable-air-volume-rate indoor fan, use the lowest fan setting allowed for heating.

3.1.4.6 Heating Intermediate Air Volume Rate. a. For ducted heat pumps that regulate the speed of the indoor fan,

$$\text{Heating Intermediate Air Volume Rate} = \text{Heating Full-load Air Volume Rate} \times \frac{H2_V\ \text{Test Fan Speed}}{H1_2\ \text{Test Fan Speed}},$$

For such heat pumps, obtain the Heating Intermediate Air Volume Rate without regard to the external static pressure.

b. For ducted heat pumps that regulate the air volume rate delivered by the indoor fan, the manufacturer must specify the Heating Intermediate Air Volume Rate. For such heat pumps, conduct the $H2_V$ Test at an external static pressure that does not cause instability or an automatic shutdown of the indoor blower while being as close to, but not less than,

$$H2_V\ \ \text{Test}\ \Delta P_{st}\Delta P_{st,\,H1_2} \times \left[\frac{\text{Heating Intermediate Air Volume Rate}}{\text{Heating Full-load Air Volume Rate}}\right]^2,$$

where $\Delta P_{st,H1_2}$

is the minimum external static pressure that was specified for the $H1_2$ Test.

c. For non-ducted heat pumps, the Heating Intermediate Air Volume Rate is the air volume rate that results when the heat pump operates at an external static pressure of zero inches of water and at the fan speed selected by the controls of the unit for the $H2_V$ Test conditions.

3.1.4.7 Heating Nominal Air Volume Rate. Except for the noted changes, determine the Heating Nominal Air Volume Rate using the approach described in section 3.1.4.6. Required changes include substituting ''$H1_N$ Test'' for $H2_V$ Test'' within the first section 3.1.4.6 equation, substituting ''$H1_N$ Test ΔP_{st}'' for ''$H2_V$ Test ΔP_{st}'' in the second section 3.1.4.6 equation, substituting ''$H1_N$ Test'' for each ''$H2_V$ Test'', and substituting ''Heating Nominal Air Volume Rate'' for each ''Heating Intermediate Air Volume Rate.''

$$\text{Heating Nominal Air Volume Rate} = \text{Heating Full-load Air Volume Rate} \times \frac{H1_N \text{Test Fan Speed}}{H1_2 \text{Test Fan Speed}},$$

$$H1_N \text{ Test } \Delta P_{st} = \Delta P_{st,\, H1_2} \times \left[\frac{\text{Heating Nominal Air Volume Rate}}{\text{Heating Full-load Air Volume Rate}}\right]^2,$$

3.1.5 Indoor test room requirement when the air surrounding the indoor unit is not supplied from the same source as the air entering the indoor unit. If using a test set-up where air is ducted directly from the air reconditioning apparatus to the indoor coil inlet (see Figure 2, Loop Air-Enthalpy Test Method Arrangement, of ASHRAE Standard 37–2005) (incorporated by reference, see §430.22), maintain the dry bulb temperature within the test room within ±5.0 °F of the applicable sections 3.2 and 3.6 dry bulb temperature test condition for the air entering the indoor unit.

3.1.6 Air volume rate calculations. For all steady-state tests and for frost accumulation ($H2$, $H2_1$, $H2_2$, $H2_V$) tests, calculate the air volume rate through the indoor coil as specified in sections 7.7.2.1 and 7.7.2.2 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22). When using the Outdoor Air Enthalpy Method, follow sections 7.7.2.1 and 7.7.2.2 to calculate the air volume rate through the outdoor coil. To express air volume rates in terms of standard air, use:

$$\bar{\dot{V}}_s = \frac{\bar{\dot{V}}_{mx}}{0.075 \frac{lbm_{da}}{ft^3} \cdot v_n' \cdot [1 + W_n]} = \frac{\bar{\dot{V}}_{mx}}{0.075 \frac{lbm_{da}}{ft^3} \cdot v_n} \qquad (3\text{-}1)$$

where,

$\bar{\dot{V}}_s$ = air volume rate of standard (dry) air, $(ft^3/min)_{da}$

$\bar{\dot{V}}_{mx}$ = air volume rate of the air-water vapor mixture, $(ft^3/min)_{mx}$

v_n' = specific volume of air-water vapor mixture at the nozzle, ft^3 per lbm of the air-water vapor mixture

W_n = humidity ratio at the nozzle, lbm of water vapor per lbm of dry air

0.075 = the density associated with standard (dry) air, (lbm/ft^3)

v_n = specific volume of the dry air portion of the mixture evaluated at the dry-bulb temperature, vapor content, and barometric pressure existing at the nozzle, ft^3 per lbm of dry air.

(Note: In the first printing of ASHRAE Standard 37–2005, the second IP equation for Q_{mi} should read,

$$1097CA_n\sqrt{P_v v_n'}\,.)***$$

3.1.7 Test sequence. When testing a ducted unit (except if a heating-only heat pump), conduct the A or A_2 Test first to establish the Cooling Full-load Air Volume Rate. For ducted heat pumps where the Heating and Cooling Full-loadAir Volume Rates are different, make the first heating mode test one that requires the Heating Full-load Air Volume Rate. For ducted heating-only heat pumps, conduct the H1 or $H1_2$ Test first to establish the Heating Full-load Air Volume Rate. When conducting an optional cyclic test, always conduct it immediately after the steady-state test that requires the same test conditions. For variable-speed systems, the first test using the Cooling Minimum Air Volume Rate should precede the E_V Test if one expects to adjust the indoor fan control options when preparing for the first Minimum Air Volume Rate test. Under the same circumstances, the first test using the Heating Minimum Air Volume Rate should precede the $H2_V$ Test. The test laboratory makes all other decisions on the test sequence.

3.1.8 Requirement for the air temperature distribution leaving the indoor coil. For at least the first cooling mode test and the first heating mode test, monitor the temperature distribution of the air leaving the indoor coil using the grid of individual sensors described in sections 2.5 and 2.5.4. For the 30-minute data collection interval used to determine capacity, the maximum spread among the outlet dry bulb temperatures from any data sampling must not exceed 1.5 °F. Install the mixing devices described in section 2.5.4.2 to minimize the temperature spread.

3.1.9 Control of auxiliary resistive heating elements. Except as noted, disable heat pump resistance elements used for heating indoor air at all times, including during defrost cycles and if they are normally regulated by a heat comfort controller. For heat pumps equipped with a heat comfort controller, enable the heat pump resistance elements only during the below-described, short test. For single-speed heat pumps covered under section 3.6.1, the short test follows the H1 or, if conducted, the H1C Test. For two-capacity heat pumps and heat pumps covered under section 3.6.2, the short test follows the $H1_2$ Test. Set the heat comfort controller to provide the maximum supply air temperature. With the heat pump operating and while maintaining the Heating Full-loadAir Volume Rate, measure the temperature of the air leaving the indoor-side beginning 5 minutes after activating the heat comfort controller. Sample the outlet dry-bulb temperature at regular intervals that span 5 minutes or less. Collect data for 10 minutes, obtaining at least 3 samples. Calculate the average outlet temperature over the 10-minute interval, T_{CC}.

3.2 Cooling mode tests for different types of air conditioners and heat pumps.

3.2.1 Tests for a unit having a single-speed compressor that is tested with a fixed-speed indoor fan installed, with a constant-air-volume-rate indoor fan installed, or with no indoor fan installed. Conduct two steady-state wet coil tests, the A and B Tests. Use the two optional dry-coil tests, the steady-state C Test and the cyclic D Test, to determine the cooling mode cyclic degradation coefficient, $C_D{}^c$. If the two optional tests are conducted but yield a tested $C_D{}^c$ that exceeds the default $C_D{}^c$ or if the two optional tests are not conducted, assign $C_D{}^c$ the default value of 0.25. Table 3 specifies test conditions for these four tests.

TABLE 3—COOLING MODE TEST CONDITIONS FOR UNITS HAVING A SINGLE-SPEED COMPRESSOR AND A FIXED-SPEED INDOOR FAN, A CONSTANT AIR VOLUME RATE INDOOR FAN, OR NO INDOOR FAN

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Cooling air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
A Test—required (steady, wet coil)	80	67	95	[1] 75	Cooling full-load [2]
B Test—required (steady, wet coil)	80	67	82	[1] 65	Cooling full-load [2]
C Test—optional (steady, dry coil)	80	([3])	82	....	Cooling full-loadthnsp;[2]
D Test—optional (cyclic, dry coil)	80	([3])	82	....	([4])

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.
[2] Defined in section 3.1.4.1.
[3] The entering air must have a low enough moisture content so no condensate forms on the indoor coil. (It is recommended that an indoor wet-bulb temperature of 57 °F or less be used.)
[4] Maintain the airflow nozzles static pressure difference or velocity pressure during the ON period at the same pressure difference or velocity pressure as measured during the C Test.

3.2.2 Tests for a unit having a single-speed compressor and a variable-speed variable-air-volume-rate indoor fan installed.

3.2.2.1 Indoor fan capacity modulation that correlates with the outdoor dry bulb temperature. Conduct four steady-state wet coil tests: The A_2, A_1 , B_2, and B_1 Tests. Use the two optional dry-coil tests, the steady-state C_1 Test and the cyclic D_1 Test, to determine the cooling mode cyclic degradation coefficient, $C_D{}^c$. If the two optional tests are conducted but yield a tested $C_D{}^c$ that exceeds the default C_D^c or if the two optional tests are not conducted, assign C_D^c the default value of 0.25

3.2.2.2 Indoor fan capacity modulation based on adjusting the sensible to total (S/T) cooling capacity ratio. The testing requirements are the same as specified in section 3.2.1 and Table 3. Use a Cooling Full-load Air Volume Rate that represents a normal residential installation. If performed, conduct the steady-state C Test and the cyclic D Test with the unit operating in the same S/T capacity control mode as used for the B Test.

TABLE 4—COOLING MODE TEST CONDITIONS FOR UNITS HAVING A SINGLE-SPEED COMPRESSOR AND A VARIABLE AIR VOLUME RATE INDOOR FAN THAT CORRELATES WITH THE OUTDOOR DRY BULB TEMPERATURE (SEC. 3.2.2.1)

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Cooling air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
A_2 Test—required (steady, wet coil)	80	67	95	[1] 75	Cooling full-load [2]
A_1 Test—required (steady, wet coil)	80	67	95	[1] 75	Cooling minimum [3]
B_2 Test—required (steady, wet coil)	80	67	82	[1] 65	Cooling full-load [2]
B_1 Test—required (steady, wet coil)	80	67	82	[1] 65	Cooling minimum [3]
C_1 Test [4]—optional (steady, dry coil)	80	(4)	82	....	Cooling minimum [3]
D_1 Test [4]—optional (cyclic, dry coil)	80	(4)	82	(5)	

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.
[2] Defined in section 3.1.4.1.
[3] Defined in section 3.1.4.2.
[4] The entering air must have a low enough moisture content so no condensate forms on the indoor coil. (It is recommended that an indoor wet-bulb temperature of 57 °F or less be used.)
[5] Maintain the airflow nozzles static pressure difference or velocity pressure during the ON period at the same pressure difference or velocity pressure as measured during the C_1 Test.

3.2.3 Tests for a unit having a two-capacity compressor. (See Definition 1.45.) a. Conduct four steady-state wet coil tests: the A_2, B_2, B_1, and F_1 Tests. Use the two optional dry-coil tests, the steady-state C_1 Test and the cyclic D_1 Test, to determine the cooling-mode cyclic-degradation coefficient, C_D^c. If the two optional tests are conducted but yield a tested C_D^c that exceeds the default C_D^c or if the two optional tests are not conducted, assign C_D^c the default value of 0.25. Table 5 specifies test conditions for these six tests.

b. For units having a variable speed indoor fan that is modulated to adjust the sensible to total (S/T) cooling capacity ratio, use Cooling Full-load and Cooling Minimum Air Volume Rates that represent a normal residential installation. Additionally, if conducting the optional dry-coil tests, operate the unit in the same S/T capacity control mode as used for the B_1 Test.

c. Test two-capacity, northern heat pumps (see Definition 1.46) in the same way as a single speed heat pump with the unit operating exclusively at low compressor capacity (see section 3.2.1 and Table 3).

d. If a two-capacity air conditioner or heat pump locks out low-capacity operation at higher outdoor temperatures, then use the two optional dry-coil tests, the steady-state C_2 Test and the cyclic D_2 Test, to determine the cooling-mode cyclic-degradation coefficient that only applies to on/off cycling from high capacity, $C_D^c(k{=}2)$. If the two optional tests are conducted but yield a tested $C_D^c(k{=}2)$ that exceeds the default $C_D^c(k{=}2)$ or if the two optional tests are not conducted, assign $C_D^c(k{=}2)$ the default value. The default $C_D^c(k{=}2)$ is the same value as determined or assigned for the low-capacity cyclic-degradation coefficient, C_D^c [or equivalently, $C_D^c(k{=}1)$].

TABLE 5—COOLING MODE TEST CONDITIONS FOR UNITS HAVING A TWO-CAPACITY COMPRESSOR

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor capacity	Cooling air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
A_2 Test—required (steady, wet coil)	80	67	95	[1] 75	High	Cooling Full-Load. [2]
B_2 Test—required (steady, wet coil)	80	67	82	[1] 65	High	Cooling Full-Load. [2]
B_1 Test—required (steady, wet coil)	80	67	82	[1] 65	Low	Cooling Minimum. [3]
C_2 Test—optional (steady, dry-coil)	80	(4)	82	High	Cooling Full-Load. [2].	
D_2 Test—optional (cyclic, dry-coil)	80	(4)	82	High	(5).	

TABLE 5—COOLING MODE TEST CONDITIONS FOR UNITS HAVING A TWO-CAPACITY COMPRESSOR—Continued

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor capacity	Cooling air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
C_1 Test—optional (steady, dry-coil)	80	([4])	82	Low	Cooling Minimum.[3].	
D_1 Test—optional (cyclic, dry-coil)	80	([4])	82	Low	([6]).	
F_1 Test—required (steady, wet coil)	80	67	67	[1] 53.5	Low	Cooling Minimum.[3]

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.
[2] Defined in section 3.1.4.1.
[3] Defined in section 3.1.4.2.
[4] The entering air must have a low enough moisture content so no condensate forms on the indoor coil. DOE recommends using an indoor air wet-bulb temperature of 57 °F or less.
[5] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the C_2 Test.
[6] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the C_1 Test.

3.2.4 Tests for a unit having a variable-speed compressor. a. Conduct five steady-state wet coil tests: The A_2, E_V, B_2, B_1, and F_1 Tests. Use the two optional dry-coil tests, the steady-state G_1 Test and the cyclic I_1 Test, to determine the cooling mode cyclic degradation coefficient, C_D^c. If the two optional tests are conducted but yield a tested C_D^c that exceeds the default C_D^c or if the two optional tests are not conducted, assign C_D^c the default value of 0.25.Table 6 specifies test conditions for these seven tests. Determine the intermediate compressor speed cited in Table 6 using:

$$\text{Intermediate speed} = \text{Minimum speed} + \frac{\text{Maximum speed} - \text{Minimum speed}}{3}$$

where a tolerance of plus 5 percent or the next higher inverter frequency step from that calculated is allowed.

b. For units that modulate the indoor fan speed to adjust the sensible to total (S/T) cooling capacity ratio, use Cooling Full-load, Cooling Intermediate, and Cooling Minimum Air Volume Rates that represent a normal residential installation. Additionally, if conducting the optional dry-coil tests, operate the unit in the same S/T capacity control mode as used for the F_1 Test.

c. For multiple-split air conditioners and heat pumps (except where noted), the following procedures supersede the above requirements: For all Table 6 tests specified for a minimum compressor speed, at least one indoor unit must be turned off. The manufacturer shall designate the particular indoor unit(s) that is turned off. The manufacturer must also specify the compressor speed used for the Table 6 E_V Test, a cooling-mode intermediate compressor speed that falls within ¼ and ¾ of the difference between the maximum and minimum cooling-mode speeds. The manufacturer should prescribe an intermediate speed that is expected to yield the highest EER for the given E_V Test conditions and bracketed compressor speed range. The manufacturer can designate that one or more indoor units are turned off for the E_V Test.

TABLE 6—COOLING MODE TEST CONDITION FOR UNITS HAVING A VARIABLE-SPEED COMPRESSOR

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Cooling air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
A_2 Test—required (steady, wet coil)	80	67	95	[1] 75	Maximum	Cooling Full-Load[2]
B_2 Test—required (steady, wet coil)	80	67	82	[1] 65	Maximum	Cooling Full-Load[2]
E_V Test—required (steady, wet coil)	80	67	87	[1] 69	Intermediate	Cooling Intermediate[3]

TABLE 6—COOLING MODE TEST CONDITION FOR UNITS HAVING A VARIABLE-SPEED COMPRESSOR—Continued

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Cooling air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
B_1 Test—required (steady, wet coil)	80	67	82	[1] 65	Minimum	Cooling Minimum [4]
F_1 Test—required (steady, wet coil)	80	67	67	[1] 53.5	Minimum	Cooling Minimum [4]
G_1 Test [5]—optional (steady, dry-coil)	80	([6])	67	Minimum	Cooling Minimum [4].	
I_1 Test [5]—optional (cyclic, dry-coil)	80	([6])	67	Minimum	([6]).	

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.
[2] Defined in section 3.1.4.1.
[3] Defined in section 3.1.4.3.
[4] Defined in section 3.1.4.2.
[5] The entering air must have a low enough moisture content so no condensate forms on the indoor coil. DOE recommends using an indoor air wet bulb temperature of 57 °F or less.
[6] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure difference or velocity pressure as measured during the G_1 Test.

3.3 Test procedures for steady-state wet coil cooling mode tests (the A, A_2, A_1, B, B_2, B_1, E_V, and F_1 Tests). a. For the pretest interval, operate the test room reconditioning apparatus and the unit to be tested until maintaining equilibrium conditions for at least 30 minutes at the specified section 3.2 test conditions. Use the exhaust fan of the airflow measuring apparatus and, if installed, the indoor fan of the test unit to obtain and then maintain the indoor air volume rate and/or external static pressure specified for the particular test. Continuously record (see Definition 1.15):

(1) The dry-bulb temperature of the air entering the indoor coil,

(2) The water vapor content of the air entering the indoor coil,

(3) The dry-bulb temperature of the air entering the outdoor coil, and

(4) For the section 2.2.4 cases where its control is required, the water vapor content of the air entering the outdoor coil.

Refer to section 3.11 for additional requirements that depend on the selected secondary test method.

b. After satisfying the pretest equilibrium requirements, make the measurements specified in Table 3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22) for the Indoor Air Enthalpy method and the user-selected secondary method. Except for external static pressure, make the Table 3 measurements at equal intervals that span 10 minutes or less. Measure external static pressure every 5 minutes or less. Continue data sampling until reaching a 30-minute period (*e.g.*, four consecutive 10-minute samples) where the test tolerances specified in Table 7 are satisfied. For those continuously recorded parameters, use the entire data set from the 30-minute interval to evaluate Table 7 compliance. Determine the average electrical power consumption of the air conditioner or heat pump over the same 30-minute interval.

c. Calculate indoor-side total cooling capacity as specified in sections 7.3.3.1 and 7.3.3.3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22). Do not adjust the parameters used in calculating capacity for the permitted variations in test conditions. Evaluate air enthalpies based on the measured barometric pressure. Assign the average total space cooling capacity and electrical power consumption over the 30-minute data collection interval to the variables $\dot{Q}_c^k(T)$ and $\dot{E}_c^k(T)$, respectively. For these two variables, replace the "T" with the nominal outdoor temperature at which the test was conducted. The superscript k is used only when testing multi-capacity units. Use the superscript k=2 to denote a test with the unit operating at high capacity or maximum speed, k=1 to denote low capacity or minimum speed, and k=v to denote the intermediate speed.

d. For units tested without an indoor fan installed, decrease $\dot{Q}_c^k(T)$ by

$$\frac{1250\ \text{Btu/h}}{1000\ \text{scfm}} \cdot \bar{\dot{V}}_s,$$

and increase $\dot{E}_c^k(T)$ by,

$$\frac{365\ \text{W}}{1000\ \text{scfm}} \cdot \bar{\dot{V}}_s,$$

where $\bar{\dot{V}}_s$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

TABLE 7—TEST OPERATING AND TEST CONDITION TOLERANCES FOR SECTION 3.3 STEADY-STATE WET COIL COOLING MODE TESTS AND SECTION 3.4 DRY COIL COOLING MODE TESTS

	Test operating tolerance [1]	Test condition tolerance [2]
Indoor dry-bulb, °F		
Entering temperature	2.0	0.5
Leaving temperature	2.0	
Indoor wet-bulb, °F		
Entering temperature	1.0	[3] 0.3
Leaving temperature	[3] 1.0	
Outdoor dry-bulb, °F		
Entering temperature	2.0	0.5
Leaving temperature	[4] 2.0	
Outdoor wet-bulb, °F		
Entering temperature	1.0	[5] 0.3
Leaving temperature	[4] 1.0	
External resistance to airflow, inches of water	0.05	[6] 0.02
Electrical voltage, % of rdg.	2.0	1.5
Nozzle pressure drop, % of rdg.	2.0	

[1] See Definition 1.41.
[2] See Definition 1.40.
[3] Only applies during wet coil tests; does not apply during steady-state, dry coil cooling mode tests.
[4] Only applies when using the Outdoor Air Enthalpy Method.
[5] Only applies during wet coil cooling mode tests where the unit rejects condensate to the outdoor coil.
[6] Only applies when testing non-ducted units.

d. For air conditioners and heat pumps having a constant-air-volume-rate indoor fan, the five additional steps listed below are required if the average of the measured external static pressures exceeds the applicable sections 3.1.4 minimum (or target) external static pressure (ΔP_{min}) by 0.03 inches of water or more.

1. Measure the average power consumption of the indoor fan motor ($\dot{E}_{fan,1}$) and record the corresponding external static pressure (ΔP_1) during or immediately following the 30-minute interval used for determining capacity.

2. After completing the 30-minute interval and while maintaining the same test conditions, adjust the exhaust fan of the airflow measuring apparatus until the external static pressure increases to approximately $\Delta P_1 + (\Delta P_1 - \Delta P_{min})$.

3. After re-establishing steady readings of the fan motor power and external static pressure, determine average values for the indoor fan power ($\dot{E}_{fan,2}$) and the external static pressure (ΔP_2) by making measurements over a 5-minute interval.

4. Approximate the average power consumption of the indoor fan motor at ΔP_{min} using linear extrapolation:

$$\dot{E}_{fan,min} = \frac{\dot{E}_{fan,2} - \dot{E}_{fan,1}}{\Delta P_2 - \Delta P_1}\left(\Delta P_{min} - \Delta P_1\right) + \dot{E}_{fan,1}.$$

5. Increase the total space cooling capacity, $\dot{Q}_c^k(T)$, by the quantity ($\dot{E}_{fan,1} - \dot{E}_{fan,min}$), when expressed on a Btu/h basis. Decrease the total electrical power, $\dot{E}_c^k(T)$, by the same fan power difference, now expressed in watts.

3.4 Test procedures for the optional steady-state dry-coil cooling-mode tests (the C, C_1, C_2, and G_1 Tests).

a. Except for the modifications noted in this section, conduct the steady-state dry coil cooling mode tests as specified in section 3.3 for wet coil tests. Prior to recording data during the steady-state dry coil test, operate the unit at least one hour after achieving dry coil conditions. Drain the drain pan and plug the drain opening. Thereafter, the drain pan should remain completely dry.

b. Denote the resulting total space cooling capacity and electrical power derived from the test as $\dot{Q}_{ss,dry}$ and $\dot{E}_{ss,dry}$. With regard to a section 3.3 deviation, do not adjust $\dot{Q}_{ss,dry}$ for duct losses (i.e., do not apply section 7.3.3.3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22)). In preparing for the section 3.5 cyclic tests, record the average indoor-side air volume rate, $\bar{V}$, specific heat of the air, Cp,a (expressed on dry air basis), specific volume of the air at the nozzles, v'_n, humidity ratio at the nozzles, W_n, and either pressure difference or velocity pressure for the flow nozzles. For units having a variable-speed indoor fan (that provides either a constant or variable air volume rate) that will or may be tested during the cyclic dry coil cooling mode test with the indoor fan turned off (see section 3.5), include the electrical power used by the indoor fan motor among the recorded parameters from the 30-minute test.

3.5 Test procedures for the optional cyclic dry-coil cooling-mode tests (the D, D_1, D_2, and I_1 Tests). a. After completing the steady-state dry-coil test, remove the Outdoor Air Enthalpy method test apparatus, if connected, and begin manual OFF/ON cycling of the unit's compressor. The test set-up should otherwise be identical to the set-up used during the steady-state dry coil test. When testing heat pumps, leave the reversing valve during the compressor OFF cycles in the same position as used for the compressor ON cycles, unless automatically changed by the controls of the unit. For units having a variable-speed indoor fan, the manufacturer has the option of electing at the outset whether to conduct the cyclic test with the indoor fan enabled or disabled. Always revert to testing with the indoor fan disabled if cyclic testing with the fan enabled is unsuccessful.

b. For units having a single-speed or two-capacity compressor, cycle the compressor OFF for 24 minutes and then ON for 6 minutes ($\Delta\tau_{cyc,dry}$ = 0.5 hours). For units having a variable-speed compressor, cycle the compressor OFF for 48 minutes and then ON for 12 minutes ($\Delta\tau_{cyc,dry}$ = 1.0 hours). Repeat the OFF/ON compressor cycling pattern until the test is completed. Allow the controls of the unit to regulate cycling of the outdoor fan.

c. Sections 3.5.1 and 3.5.2 specify airflow requirements through the indoor coil of ducted and non-ducted systems, respectively. In all cases, use the exhaust fan of the airflow measuring apparatus (covered under section 2.6) along with the indoor fan of the unit, if installed and operating, to approximate a step response in the indoor coil airflow. Regulate the exhaust fan to quickly obtain and then maintain the flow nozzle static pressure difference or velocity pressure at the same value as was measured during the steady-state dry coil test. The pressure difference or velocity pressure should be within 2 percent of the value from the steady-state dry coil test within 15 seconds after airflow initiation. For units having a variable-speed indoor fan that ramps when cycling on and/or off, use the exhaust fan of the airflow measuring apparatus to impose a step response that begins at the initiation of ramp up and ends at the termination of ramp down.

d. For units having a variable-speed indoor fan, conduct the cyclic dry coil test using the pull-thru approach described below if any of the following occur when testing with the fan operating:

(1) The test unit automatically cycles off;

(2) Its blower motor reverses; or

(3) The unit operates for more than 30 seconds at an external static pressure that is 0.1 inches of water or more higher than the value measured during the prior steady-state test.

For the pull-thru approach, disable the indoor fan and use the exhaust fan of the airflow measuring apparatus to generate the specified flow nozzles static pressure difference or velocity pressure. If the exhaust fan cannot deliver the required pressure difference because of resistance created by the unpowered blower, temporarily remove the blower.

e. After completing a minimum of two complete compressor OFF/ON cycles, determine the overall cooling delivered and total electrical energy consumption during any subsequent data collection interval where the test tolerances given in Table 8 are satisfied. If available, use electric resistance heaters (see section 2.1) to minimize the variation in the inlet air temperature.

f. With regard to the Table 8 parameters, continuously record the dry-bulb temperature of the air entering the indoor and outdoor coils during periods when air flows through the respective coils. Sample the water vapor content of the indoor coil inlet air at least every 2 minutes during periods when air flows through the coil. Record external static pressure and the air volume rate indicator (either nozzle pressure difference or velocity pressure) at least every minute during the interval that air flows through the indoor coil. (These regular measurements of the airflow rate indicator are in addition to the required measurement at 15 seconds after flow initiation.) Sample the electrical voltage at least every 2 minutes beginning 30 seconds after compressor start-up. Continue until the compressor, the outdoor fan, and the indoor fan (if it is installed and operating) cycle off.

g. For ducted units, continuously record the dry-bulb temperature of the air entering (as noted above) and leaving the indoor coil. Or if using a thermopile, continuously record the difference between these two temperatures during the interval that air flows through the indoor coil. For non-ducted units, make the same dry-bulb temperature measurements beginning when the compressor cycles on and ending when indoor coil airflow ceases.

h. Integrate the electrical power over complete cycles of length $\Delta\tau_{cyc,dry}$. For ducted units tested with an indoor fan installed and operating, integrate electrical power from indoor fan OFF to indoor fan OFF. For all other ducted units and for non-ducted units, integrate electrical power from compressor OFF to compressor OFF. (Some cyclic tests will use the same data collection intervals to determine the electrical energy and the total space cooling. For other units, terminate data collection used to determine the electrical energy before terminating data collection used to determine total space cooling.)

TABLE 8—TEST OPERATING AND TEST CONDITION TOLERANCES FOR CYCLIC DRY COIL COOLING MODE TESTS

	Test Operating Tolerance [1]	Test Condition Tolerance [2]
Indoor entering dry-bulb temperature [3], °F	2.0	0.5
Indoor entering wet-bulb temperature, °F	....	(4)
Outdoor entering dry-bulb temperature [3], °F	2.0	0.5
External resistance to airflow [3], inches of water	0.05	
Airflow nozzle pressure difference or velocity pressure [3], % of reading	2.0	[5] 2.0
Electrical voltage [6], % of rdg.	2.0	1.5

[1] See Definition 1.41.
[2] See Definition 1.40.
[3] Applies during the interval that air flows through the indoor (outdoor) coil except for the first 30 seconds after flow initiation. For units having a variable-speed indoor fan that ramps, the tolerances listed for the external resistance to airflow apply from 30 seconds after achieving full speed until ramp down begins.
[4] Shall at no time exceed a wet-bulb temperature that results in condensate forming on the indoor coil.
[5] The test condition shall be the average nozzle pressure difference or velocity pressure measured during the steady-state dry coil test.
[6] Applies during the interval when at least one of the following—the compressor, the outdoor fan, or, if applicable, the indoor fan—are operating except for the first 30 seconds after compressor start-up.

i. If the Table 8 tolerances are satisfied over the complete cycle, record the measured electrical energy consumption as $e_{cyc,dry}$ and express it in units of watt-hours. Calculate the total space cooling delivered, $q_{cyc,dry}$, in units of Btu using,

$$q_{cyc,dry} = \frac{60 \cdot \overline{\dot{V}} \cdot C_{p,a} \cdot \Gamma}{\left[v'_n \cdot \left(1 + W_n\right) \right]} = \frac{60 \cdot \overline{\dot{V}} \cdot C_{p,a} \cdot \Gamma}{v_n} \qquad (3.5\text{-}1)$$

where $\overline{\dot{V}}$, $C_{p,a}$, v_n' (or v_n), and W_n are the values recorded during the section 3.4 dry coil steady-state test and,

$$\Gamma = \int_{\tau_1}^{\tau_2} \left[T_{al}(\tau) - T_{a2}(\tau) \right] d\tau \text{ , hr} \cdot {}^\circ\text{F.}$$

$T_{al}(\tau)$ = dry bulb temperature of the air entering the indoor coil at time τ, °F.

$T_{a2}(\tau)$ = dry bulb temperature of the air leaving the indoor coil at time τ, °F.

τ_1 = for ducted units, the elapsed time when airflow is initiated through the indoor coil; for non-ducted units, the elapsed time when the compressor is cycled on, hr.

τ_2 = the elapsed time when indoor coil airflow ceases, hr.

3.5.1 Procedures when testing ducted systems. The automatic controls that are normally installed with the test unit must govern the OFF/ON cycling of the air moving equipment on the indoor side (exhaust fan of the airflow measuring apparatus and, if installed, the indoor fan of the test unit). For example, for ducted units tested without an indoor fan installed but rated based on using a fan time delay relay, control the indoor coil airflow according to the rated ON and/or OFF delays provided by the relay. For ducted units having a variable-speed indoor fan that has been disabled (and possibly removed), start and stop the indoor airflow at the same instances as if the fan were enabled. For all other ducted units tested without an indoor fan installed, cycle the indoor coil airflow in unison with the cycling of the compressor. Close air dampers on the inlet (section 2.5.1) and outlet side (sections 2.5 and 2.5.4) during the OFF period. Airflow through the indoor coil should stop within 3 seconds after the automatic controls of the test unit (act to) de-energize the indoor fan. For ducted units tested without an indoor fan installed (excluding the special case where a variable-speed fan is temporarily removed), increase $e_{cyc,dry}$ by the quantity,

$$\frac{365 \text{ W}}{1000 \text{ scfm}} \cdot \overline{\dot{V}}_s \cdot \left[\tau_2 - \tau_1 \right], \qquad (3.5\text{-}2)$$

and decrease $q_{cyc,dry}$ by,

$$\frac{1250 \text{ Btu/h}}{1000 \text{ scfm}} \cdot \overline{\dot{V}}_s \cdot \left[\tau_2 - \tau_1 \right], \qquad (3.5\text{-}3)$$

where $\overline{\dot{V}}_s$ is the average indoor air volume rate from the section 3.4 dry coil steady-state test and is expressed in units of cubic feet per minute of standard air (scfm). For units having a variable-speed indoor fan that is disabled during the cyclic test, increase $e_{cyc,dry}$ and decrease $q_{cyc,dry}$ based on:

a. The product of $[\tau_2 - \tau_1]$ and the indoor fan power measured during or following the dry coil steady-state test; or,

b. The following algorithm if the indoor fan ramps its speed when cycling.

1. Measure the electrical power consumed by the variable-speed indoor fan at a minimum of three operating conditions: at the speed/air volume rate/external static pressure that was measured during the steady-state test, at operating conditions associated with the midpoint of the ramp-up interval, and at conditions associated with the midpoint of the ramp-down interval. For these measurements, the tolerances on the airflow

volume or the external static pressure are the same as required for the section 3.4 steady-state test.

2. For each case, determine the fan power from measurements made over a minimum of 5 minutes.

3. Approximate the electrical energy consumption of the indoor fan if it had operated during the cyclic test using all three power measurements. Assume a linear profile during the ramp intervals. The manufacturer must provide the durations of the ramp-up and ramp-down intervals. If a manufacturer-supplied ramp interval exceeds 45 seconds, use a 45-second ramp interval nonetheless when estimating the fan energy.

The manufacturer is allowed to choose option a, and forego the extra testing burden of option b, even if the unit ramps indoor fan speed when cycling.

3.5.2 Procedures when testing non-ducted systems. Do not use air dampers when conducting cyclic tests on non-ducted units. Until the last OFF/ON compressor cycle, airflow through the indoor coil must cycle off and on in unison with the compressor. For the last OFF/ON compressor cycle—the one used to determine $e_{cyc,dry}$ and $q_{cyc,dry}$—use the exhaust fan of the airflow measuring apparatus and the indoor fan of the test unit to have indoor airflow start 3 minutes prior to compressor cut-on and end three minutes after compressor cutoff. Subtract the electrical energy used by the indoor fan during the 3 minutes prior to compressor cut-on from the integrated electrical energy, $e_{cyc,dry}$. Add the electrical energy used by the indoor fan during the 3 minutes after compressor cutoff to the integrated cooling capacity, $q_{cyc,dry}$. For the case where the non-ducted unit uses a variable-speed indoor fan which is disabled during the cyclic test, correct $e_{cyc,dry}$ and $q_{cyc,dry}$ using the same approach as prescribed in section 3.5.1 for ducted units having a disabled variable-speed indoor fan.

3.5.3 Cooling-mode cyclic-degradation coefficient calculation. Use the two optional dry-coil tests to determine the cooling-mode cyclic-degradation coefficient, C_D^c. Append ''(k=2)'' to the coefficient if it corresponds to a two-capacity unit cycling at high capacity. If the two optional tests are conducted but yield a tested C_D^c that exceeds the default C_D^c or if the two optional tests are not conducted, assign C_D^c the default value of 0.25. The default value for two-capacity units cycling at high capacity, however, is the low-capacity coefficient, i.e., $C_D^c(k=2)=C_D^c$. Evaluate C_D^c using the above results and those from the section 3.4 dry-coil steady-state test.

$$C_D^c = \frac{1 - \dfrac{EER_{cyc,dry}}{EER_{ss,dry}}}{1 - CLF}$$

where,

$$EER_{cyc,dry} = \frac{q_{cyc,dry}}{e_{cyc,dry}},$$

the average energy efficiency ratio during the cyclic dry coil cooling mode test, Btu/W·h

$$EER_{ss,dry} = \frac{\dot{Q}_{ss,dry}}{\dot{E}_{ss,dry}},$$

the average energy efficiency ratio during the steady-state dry coil cooling mode test, Btu/W·h

$$CLF = \frac{q_{cyc,dry}}{Q_{ss,dry} \cdot \Delta\tau_{cyc,dry}},$$

the cooling load factor dimensionless.

Round the calculated value for C_D^c to the nearest 0.01. If C_D^c is negative, then set it equal to zero.

3.6 Heating mode tests for different types of heat pumps, including heating-only heat pumps.

3.6.1 Tests for a heat pump having a single-speed compressor that is tested with a fixed speed indoor fan installed, with a constant-air-volume-rate indoor fan installed, or with no indoor fan installed. Conduct the optional High Temperature Cyclic (H1C) Test to determine the heating mode cyclic-degradation coefficient, C_D^h. If this optional test is conducted but yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. Test conditions for the four tests are specified in Table 9.

TABLE 9—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A SINGLE-SPEED COMPRESSOR AND A FIXED-SPEED INDOOR FAN, A CONSTANT AIR VOLUME RATE INDOOR FAN, OR NO INDOOR FAN

Test description	Air entering indoor unit Temperature (°F)		Air entering outdoor unit Temperature (°F)		Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
H1 Test (required, steady)	70	60(max)	47	43	Heating Full-load [1]
H1C Test (optional, cyclic)	70	60(max)	47	43	([2])
H2 Test (required)	70	60(max)	35	33	Heating Full-load [1]

TABLE 9—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A SINGLE-SPEED COMPRESSOR AND A FIXED-SPEED INDOOR FAN, A CONSTANT AIR VOLUME RATE INDOOR FAN, OR NO INDOOR FAN—Continued

Test description	Air entering indoor unit Temperature (°F)		Air entering outdoor unit Temperature (°F)		Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
H3 Test (required, steady)	70	60(max)	17	15	Heating Full-load [1]

[1] Defined in section 3.1.4.4.
[2] Maintain the airflow nozzles static pressure difference or velocity pressure during the ON period at the same pressure difference or velocity pressure as measured during the H1 Test.

3.6.2 Tests for a heat pump having a single-speed compressor and a variable-speed, variable-air-volume-rate indoor fan: capacity modulation correlates with outdoor dry bulb temperature. Conduct five tests: two High Temperature Tests ($H1_2$ and $H1_1$), one Frost Accumulation Test ($H2_2$), and two Low Temperature Tests ($H3_2$ and $H3_1$). Conducting an additional Frost Accumulation Test ($H2_1$) is optional. Conduct the optional High Temperature Cyclic ($H1C_1$) Test to determine the heating mode cyclic-degradation coefficient, C_D^h. If this optional test is conducted but yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. Test conditions for the seven tests are specified in Table 10. If the optional $H2_1$ Test is not performed, use the following equations to approximate the capacity and electrical power of the heat pump at the $H2_1$ test conditions:

$$\dot{Q}_h^{k=1}(35) = QR_h^{k=2}(35) \cdot \left\{\dot{Q}_h^{k=1}(17) + 0.6 \cdot \left[\dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=1}(17)\right]\right\}$$

$$\dot{E}_h^{k=1}(35) = PR_h^{k=2}(35) \cdot \left\{\dot{E}_h^{k=1}(17) + 0.6 \cdot \left[\dot{E}_h^{k=1}(47) - \dot{E}_h^{k=1}(17)\right]\right\}$$

where,

$$\dot{Q}R_h^{k=2}(35) = \frac{\dot{Q}_h^{k=2}(35)}{\dot{Q}^{k=2}(17) + 0.6 \cdot \left[\dot{Q}_h^{k=2}(47) - \dot{Q}_h^{k=2}(17)\right]}$$

$$PR_h^{k=2}(35) = \frac{\dot{E}_h^{k=2}(35)}{\dot{E}_h^{k=2}(17) + 0.6 \cdot \left[\dot{E}_h^{k=2}(47) - \dot{E}_h^{k=2}(17)\right]}.$$

The quantities $\dot{Q}_h^{k=2}(47)$, $\dot{E}_h^{k=2}(47)$, $\dot{Q}_h^{k=1}(47)$, and $\dot{E}_h^{k=1}(47)$ are determined from the $H1_2$ and $H1_1$ Tests and evaluated as specified in section 3.7; the quantities $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ are determined from the $H2_2$ Test and evaluated as specified in section 3.9; and the quantities $\dot{Q}_h^{k=2}(17)$, $\dot{E}_h^{k=2}(17)$, $\dot{Q}_h^{k=1}(17)$, and $\dot{E}_h^{k=1}(17)$, are determined from the $H3_2$ and $H3_1$ Tests and evaluated as specified in section 3.10.

TABLE 10—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A SINGLE-SPEED COMPRESSOR AND A VARIABLE AIR VOLUME RATE INDOOR FAN

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
$H1_2$ Test (required, steady) ..	70	60(max)	47	43	Heating Full-load. [1]
$H1_1$ Test (required, steady) ..	70	60(max)	47	43	Heating Minimum. [2]
$H1C_1$ Test (optional, cyclic)	70	60(max)	47	43	([3])
$H2_2$ Test (required)	70	60(max)	35	33	Heating Full-load. [1]

TABLE 10—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A SINGLE-SPEED COMPRESSOR AND A VARIABLE AIR VOLUME RATE INDOOR FAN—Continued

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
$H2_1$ Test (optional)	70	60(max)	35	33	Heating Minimum.[2]
$H3_2$ Test (required, steady)	70	60(max)	17	15	Heating Full-load.[1]
$H3_1$ Test (required, steady)	70	60(max)	17	15	Heating Minimum.[2]

[1] Defined in section 3.1.4.4.
[2] Defined in section 3.1.4.5.
[3] Maintain the airflow nozzles static pressure difference or velocity pressure during the ON period at the same pressure difference or velocity pressure as measured during the $H1_1$ Test.

3.6.3 Tests for a heat pump having a two-capacity compressor (see Definition 1.45), including two-capacity, northern heat pumps (see Definition 1.46). a. Conduct one Maximum Temperature Test ($H0_1$), two High Temperature Tests ($H1_2$ and $H1_1$), one Frost Accumulation Test ($H2_2$), and one Low Temperature Test ($H3_2$). Conduct an additional Frost Accumulation Test ($H2_1$) and Low Temperature Test ($H3_1$) if both of the following conditions exist:

1. Knowledge of the heat pump's capacity and electrical power at low compressor capacity for outdoor temperatures of 37 °F and less is needed to complete the section 4.2.3 seasonal performance calculations; and

2.The heat pump's controls allow low-capacity operation at outdoor temperatures of 37 °F and less.

If the above two conditions are met, an alternative to conducting the $H2_1$ Frost Accumulation is to use the following equations to approximate the capacity and electrical power:

$$\dot{Q}_h^{k=1}(35) = 0.90 \cdot \left\{\dot{Q}_h^{k=1}(17) + 0.6 \cdot \left[\dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=1}(17)\right]\right\}$$
$$\dot{E}_h^{k=1}(35) = 0.985 \cdot \left\{\dot{E}_h^{k=1}(17) + 0.6 \cdot \left[\dot{E}_h^{k=1}(47) - \dot{E}_h^{k=1}(17)\right]\right\}$$

Determine the quantities $\dot{Q}_h^{k=1}$ (47) and $\dot{E}_h^{k=1}$ (47) from the $H1_1$ Test and evaluate them according to Section 3.7. Determine the quantities $\dot{Q}_h^{k=1}$ (17) and $\dot{E}_h^{k=1}$ (17) from the $H3_1$ Test and evaluate them according to Section 3.10.

b. Conduct the optional High Temperature Cyclic Test ($H1C_1$) to determine the heating-mode cyclic-degradation coefficient, C_D^h. If this optional test is conducted but yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. If a two-capacity heat pump locks out low capacity operation at lower outdoor temperatures, conduct the optional High Temperature Cyclic Test ($H1C_2$) to determine the high-capacity heating-mode cyclic-degradation coefficient, C_D^h (k=2). If this optional test at high capacity is conducted but yields a tested C_D^h (k=2) that exceeds the default C_D^h (k=2) or if the optional test is not conducted, assign C_D^h the default value. The default C_D^h (k=2) is the same value as determined or assigned for the low-capacity cyclic-degradation coefficient, C_D^h [or equivalently, C_D^h (k=1)]. Table 11 specifies test conditions for these nine tests.

TABLE 11—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A TWO-CAPACITY COMPRESSOR

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor capacity	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H0_1$ Test (required, steady)	70	60(max)	62	56.5	Low	Heating Minimum.[1]
$H1_2$ Test (required, steady)	70	60(max)	47	43	High	Heating Full-Load.[2]
$H1C_2$ Test (optional, cyclic)	70	60(max)	47	43	High	([3])
$H1_1$ Test (required)	70	60(max)	47	43	Low	Heating Minimum.[1]

TABLE 11—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A TWO-CAPACITY COMPRESSOR—Continued

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor capacity	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
H1C₁ Test .... (optional, cyclic)	70	60(max)	47	43	Low	(4)
H2₂ Test .... (required)	70	60(max)	35	33	High	Heating Full-Load. [2]
H2₁ Test[5,6] .... (required)	70	60(max)	35	33	Low	Heating Minimum. [1]
H3₂ Test .... (required, steady)	70	60(max)	17	15	High	Heating Full-Load. [2]
H3₁ Test [5] .... (required, steady)	70	60(max)	17	15	Low	Heating Minimum. [1]

[1] Defined in section 3.1.4.5.
[2] Defined in section 3.1.4.4.
[3] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the *$H1_2$* Test.
[4] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the *$H1_1$* Test.
[5] Required only if the heat pump's performance when operating at low compressor capacity and outdoor temperatures less than 37 °F is needed to complete the section 4.2.3 *HSPF* calculations.
[6] If table note #5 applies, the section 3.6.3 equations for $\dot{Q}_h^{k=1}$ (35) and $\dot{E}_h^{k=1}$ (17) may be used in lieu of conducting the $H2_1$ Test.

3.6.4 Tests for a heat pump having a variable-speed compressor. a. Conduct one Maximum Temperature Test ($H0_1$), two High Temperature Tests ($H1_2$ and $H1_1$), one Frost Accumulation Test ($H2_V$), and one Low Temperature Test ($H3_2$). Conducting one or both of the following tests is optional: An additional High Temperature Test ($H1_N$) and an additional Frost Accumulation Test ($H2_2$). Conduct the optional Maximum Temperature Cyclic ($H0C_1$) Test to determine the heating mode cyclic-degradation coefficient, C_D^h. If this optional test is conducted but yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. Test conditions for the eight tests are specified in Table 12. Determine the intermediate compressor speed cited in Table 12 using the heating mode maximum and minimum compressors speeds and:

$$\text{Intermediate speed} = \text{Minimum speed} + \frac{\text{Maximum speed} - \text{Minimum speed}}{3}$$

where a tolerance of plus 5 percent or the next higher inverter frequency step from that calculated is allowed. If the $H2_2$ Test is not done, use the following equations to approximate the capacity and electrical power at the $H2_2$ test conditions:

$$\dot{Q}_h^{k=2}(35) = 0.90 \cdot \left\{\dot{Q}_h^{k=2}(17) + 0.6 \cdot \left[\dot{Q}_h^{k=2}(47) - \dot{Q}_h^{k=2}(17)\right]\right\}$$

$$\dot{E}_h^{k=2}(35) = 0.985 \cdot \left\{\dot{E}_h^{k=2}(17) + 0.6 \cdot \left[\dot{E}_h^{k=2}(47) - \dot{E}_h^{k=2}(17)\right]\right\}.$$

b. Determine the quantities $\dot{Q}_h^{k=2}(47)$ and from $\dot{E}_h^{k=2}(47)$ from the $H1_2$ Test and evaluate them according to section 3.7. Determine the quantities $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ Test and evaluate them according to section 3.10. For heat pumps where the heating mode maximum compressor speed exceeds its cooling mode maximum compressor speed, conduct the $H1_N$ Test if the manufacturer requests it. If the $H1_N$ Test is done, operate the heat pump's compressor at the same speed as the speed used for the cooling mode A_2 Test. Refer to the last sentence of section 4.2 to see how the results of the $H1_N$ Test may be used in calculating the heating seasonal performance factor.

TABLE 12—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A VARIABLE-SPEED COMPRESSOR

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H0_1$ Test (required, steady)	70	$60^{(max)}$	62	56.5	Minimum	Heating Minimum.[1]
$H0C_1$ Test (optional, steady)	70	$60^{(max)}$	62	56.5	Minimum	([2])
$H1_2$ Test (required, steady)	70	$60^{(max)}$	47	43	Maximum	Heating Full-Load.[3]
$H1_1$ Test (required, steady)	70	$60^{(max)}$	47	43	Minimum	Heating Minimum.[1]
$H1_N$ Test (optional, steady)	70	$60^{(max)}$	47	43	Cooling Mode Maximum.	Heating Nominal.[4]
$H2_2$ Test (optional)	70	$60^{(max)}$	35	33	Maximum	Heating Full-Load.[3]
$H2_V$ Test (required)	70	$60^{(max)}$	35	33	Intermediate	Heating Intermediate.[5]
$H3_2$ Test (required, steady)	70	$60^{(max)}$	17	15	Maximum	Heating Full-Load.[3]

[1] Defined in section 3.1.4.5.
[2] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H0_1$ Test.
[3] Defined in section 3.1.4.4.
[4] Defined in section 3.1.4.7.
[5] Defined in section 3.1.4.6.

c. For multiple-split heat pumps (only), the following procedures supersede the above requirements. For all Table 12 tests specified for a minimum compressor speed, at least one indoor unit must be turned off. The manufacturer shall designate the particular indoor unit(s) that is turned off. The manufacturer must also specify the compressor speed used for the Table 12 $H2_V$ Test, a heating-mode intermediate compressor speed that falls within ¼ and ¾ of the difference between the maximum and minimum heating-mode speeds. The manufacturer should prescribe an intermediate speed that is expected to yield the highest COP for the given $H2_V$ Test conditions and bracketed compressor speed range. The manufacturer can designate that one or more specific indoor units are turned off for the $H2_V$ Test.

3.6.5 Additional test for a heat pump having a heat comfort controller. Test any heat pump that has a heat comfort controller (see Definition 1.28) according to section 3.6.1, 3.6.2, or 3.6.3, whichever applies, with the heat comfort controller disabled. Additionally, conduct the abbreviated test described in section 3.1.9 with the heat comfort controller active to determine the system's maximum supply air temperature. (Note: heat pumps having a variable speed compressor and a heat comfort controller are not covered in the test procedure at this time.)

3.7 Test procedures for steady-state Maximum Temperature and High Temperature heating mode tests (the $H0_1$, H1, $H1_2$, $H1_1$, and $H1_N$ Tests). a. For the pretest interval, operate the test room reconditioning apparatus and the heat pump until equilibrium conditions are maintained for at least 30 minutes at the specified section 3.6 test conditions. Use the exhaust fan of the airflow measuring apparatus and, if installed, the indoor fan of the heat pump to obtain and then maintain the indoor air volume rate and/or the external static pressure specified for the particular test. Continuously record the dry-bulb temperature of the air entering the indoor coil, and the dry-bulb temperature and water vapor content of the air entering the outdoor coil. Refer to section 3.11 for additional requirements that depend on the selected secondary test method. After satisfying the pretest equilibrium requirements, make the measurements specified in Table 3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22) for the Indoor Air Enthalpy method and the user-selected secondary method. Except for external static pressure, make the Table 3 measurements at equal intervals that span 10 minutes or less. Measure external static pressure every 5 minutes or less. Continue data sampling until a 30-minute period (*e.g.*, four consecutive 10-minute samples) is reached where the test tolerances specified in Table 13 are satisfied. For those continuously recorded parameters, use the entire data set for the 30-minute interval when evaluating Table 13 compliance. Determine the average electrical power consumption of the heat pump over the same 30-minute interval.

TABLE 13—TEST OPERATING AND TEST CONDITION TOLERANCES FOR SECTION 3.7 AND SECTION 3.10 STEADY-STATE HEATING MODE TESTS

	Test operating tolerance [1]	Test condition tolerance [2]
Indoor dry-bulb, °F:		
Entering temperature	2.0	0.5
Leaving temperature	2.0	
Indoor wet-bulb, °F:		
Entering temperature	1.0	
Leaving temperature	1.0	
Outdoor dry-bulb, °F:		
Entering temperature	2.0	0.5
Leaving temperature	[2] 2.0	
Outdoor wet-bulb, °F:		
Entering temperature	1.0	0.3
Leaving temperature	[3] 1.0	
External resistance to airflow, inches of water	0.05	[4] 0.02
Electrical voltage, % of rdg	2.0	1.5
Nozzle pressure drop, % of rdg	2.0	

[1] See Definition 1.41.
[2] See Definition 1.40.
[3] Only applies when the Outdoor Air Enthalpy Method is used.
[4] Only applies when testing non-ducted units.

b. Calculate indoor-side total heating capacity as specified in sections 7.3.4.1 and 7.3.4.3 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.22). Do not adjust the parameters used in calculating capacity for the permitted variations in test conditions. Assign the average space heating capacity and electrical power over the 30-minute data collection interval to the variables $\dot{Q}_h^k$ and $\dot{E}_h^k(T)$ respectively. The "T" and superscripted "k" are the same as described in section 3.3. Additionally, for the heating mode, use the superscript to denote results from the optional $H1_N$ Test, if conducted.

c. For heat pumps tested without an indoor fan installed, increase $\dot{Q}_h^k(T)$ by

$$\frac{1250\ \text{Btu/h}}{1000\ \text{scfm}} \cdot \overline{\dot{V}}_s,$$

and increase $\dot{E}_h^k(T)$ by,

$$\frac{365\ \text{W}}{1000\ \text{scfm}} \cdot \overline{\dot{V}}_s,$$

where $\overline{\dot{V}}_s$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm). During the 30-minute data collection interval of a High Temperature Test, pay attention to preventing a defrost cycle. Prior to this time, allow the heat pump to perform a defrost cycle if automatically initiated by its own controls. As in all cases, wait for the heat pump's defrost controls to automatically terminate the defrost cycle. Heat pumps that undergo a defrost should operate in the heating mode for at least 10 minutes after defrost termination prior to beginning the 30-minute data collection interval. For some heat pumps, frost may accumulate on the outdoor coil during a High Temperature test. If the indoor coil leaving air temperature or the difference between the leaving and entering air temperatures decreases by more than 1.5 °F over the 30-minute data collection interval, then do not use the collected data to determine capacity. Instead, initiate a defrost cycle. Begin collecting data no sooner than 10 minutes after defrost termination. Collect 30 minutes of new data during which the Table 13 test tolerances are satisfied. In this case, use only the results from the second 30-minute data collection interval to evaluate $\dot{Q}_h^k(47)$ and $\dot{E}_h^k(47)$.

d. If conducting the optional cyclic heating mode test, which is described in section 3.8, record the average indoor-side air volume rate, $\dot{V}$, specific heat of the air, $C_{p,a}$ (expressed on dry air basis), specific volume of the air at the nozzles, v_n' (or v_n), humidity ratio at the nozzles, W_n, and either pressure difference or velocity pressure for the flow nozzles. If either or both of the below criteria apply, determine the average, steady-state, electrical power consumption of the indoor fan motor ($\dot{E}_{fan,1}$):

1. The section 3.8 cyclic test will be conducted and the heat pump has a variable-speed indoor fan that is expected to be disabled during the cyclic test; or

2. The heat pump has a (variable-speed) constant-air volume-rate indoor fan and during the steady-state test the average external static pressure (ΔP_1) exceeds the applicable section 3.1.4.4 minimum (or targeted) external static pressure (ΔP_{min}) by 0.03 inches of water or more.

Determine $\dot{E}_{fan,1}$ by making measurements during the 30-minute data collection interval, or immediately following the test and prior to changing the test conditions. When the above "2" criteria applies, conduct the following four steps after determining $\dot{E}_{fan,1}$ (which corresponds to ΔP_1):

i. While maintaining the same test conditions, adjust the exhaust fan of the airflow measuring apparatus until the external static pressure increases to approximately $\Delta P_1 + (\Delta P_1 - \Delta P_{min})$.

ii. After re-establishing steady readings for fan motor power and external static pressure, determine average values for the indoor fan power ($\dot{E}_{fan,2}$) and the external static pressure (ΔP_2) by making measurements over a 5-minute interval.

iii. Approximate the average power consumption of the indoor fan motor if the 30-minute test had been conducted at ΔP_{min} using linear extrapolation:

$$\dot{E}_{fan,min} = \frac{\dot{E}_{fan,2} - \dot{E}_{fan,1}}{\Delta P_2 - \Delta P_1}\left(\Delta P_{min} - \Delta P_1\right) + \dot{E}_{fan,1}.$$

iv. Decrease the total space heating capacity, $\dot{Q}_h^k(T)$, by the quantity ($\dot{E}_{fan,1} - \dot{E}_{fan,min}$), when expressed on a Btu/h basis. Decrease the total electrical power, $\dot{E}_h^k(T)$ by the same fan power difference, now expressed in watts.

3.8 Test procedures for the optional cyclic heating mode tests (the $H0C_1$, H1C, $H1C_1$ and $H1C_2$ Tests). a. Except as noted below, conduct the cyclic heating mode test as specified in section 3.5. As adapted to the heating mode, replace section 3.5 references to "the steady-state dry coil test" with "the heating mode steady-state test conducted at the same test conditions as the cyclic heating mode test." Use the test tolerances in Table 14 rather than Table 8. Record the outdoor coil entering wet-bulb temperature according to the requirements given in section 3.5 for the outdoor coil entering dry-bulb temperature. Drop the subscript "dry" used in variables cited in section 3.5 when referring to quantities from the cyclic heating mode test. Determine the total space heating delivered during the cyclic heating test, q_{cyc}, as specified in section 3.5 except for making the following changes:

(1) When evaluating Equation 3.5–1, use the values of $\bar{\dot{V}}$, $C_{p,a}$,v_n', (or v_n), and W_n that were recorded during the section 3.7 steady-state test conducted at the same test conditions.

(2) Calculate Γ using,

$$\Gamma = \int_{\tau_1}^{\tau_2} \left[T_{a2}(\tau) - T_{a1}(\tau)\right]\delta\tau,\ \text{hr} \cdot {}^\circ\text{F}.$$

b. For ducted heat pumps tested without an indoor fan installed (excluding the special case where a variable-speed fan is temporarily removed), increase q_{cyc} by the amount calculated using Equation 3.5–3. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5–2. In making these calculations, use the average indoor air volume rate ($\bar{\dot{V}}_s$) determined from the section 3.7 steady-state heating mode test conducted at the same test conditions.

c. For non-ducted heat pumps, subtract the electrical energy used by the indoor fan during the 3 minutes after compressor cutoff from the non-ducted heat pump's integrated heating capacity, q_{cyc}.

d. If a heat pump defrost cycle is manually or automatically initiated immediately prior to or during the OFF/ON cycling, operate the heat pump continuously until 10 minutes after defrost termination. After that, begin cycling the heat pump immediately or delay until the specified test conditions have been re-established. Pay attention to preventing defrosts after beginning the cycling process. For heat pumps that cycle off the indoor fan during a defrost cycle, make no effort here to restrict the air movement through the indoor coil while the fan is off. Resume the OFF/ON cycling while conducting a minimum of two complete compressor OFF/ON cycles before determining q_{cyc} and e_{cyc}.

3.8.1 Heating mode cyclic-degradation coefficient calculation. Use the results from the optional cyclic test and the required steady-state test that were conducted at the same test conditions to determine the heating-mode cyclic-degradation coefficient C_D^h. Add "(k=2)" to the coefficient if it corresponds to a two-capacity unit cycling at high capacity. For the below calculation of the heating mode cyclic degradation coefficient, do not include the duct loss correction from section 7.3.3.3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22) in determining $\dot{Q}_h^k(T_{cyc})$ (or q_{cyc}). If the optional cyclic test is conducted but yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. The default value for two-capacity units cycling at high capacity, however, is the low-capacity coefficient, i.e., C_D^h (k=2) = C_D^h. The tested C_D^h is calculated as follows:

$$C_D^h = \frac{1 - \dfrac{COP_{cyc}}{COP_{ss}\left(T_{cyc}\right)}}{1 - HLF}$$

where,

$$COP_{cyc} = \frac{q_{cyc}}{3.413 \dfrac{\text{Btu/h}}{\text{W}} \cdot e_{cyc}},$$

the average coefficient of performance during the cyclic heating mode test, dimensionless.

$$COP_{ss}\left(T_{cyc}\right) = \frac{\dot{Q}_h^k\left(T_{cyc}\right)}{3.413 \dfrac{\text{Btu/h}}{\text{W}} \cdot \dot{E}_h^k\left(T_{cyc}\right)},$$

the average coefficient of performance during the steady-state heating mode test conducted at the same test conditions—*i.e.*, same outdoor dry bulb temperature, T_{cyc}, and speed/capacity, k, if applicable—as specified for the cyclic heating mode test, dimensionless.

$$HLF = \frac{q_{cyc}}{\dot{Q}_h^k\left(T_{cyc}\right) \cdot \Delta\tau_{cyc}},$$

the heating load factor, dimensionless.

T_{cyc} = the nominal outdoor temperature at which the cyclic heating mode test is conducted, 62 or 47 °F.

$\Delta\tau_{cyc}$ = the duration of the OFF/ON intervals; 0.5 hours when testing a heat pump having a single-speed or two-capacity compressor and 1.0 hour when testing a heat pump having a variable-speed compressor.

Round the calculated value for C_D^h to the nearest 0.01. If C_D^h is negative, then set it equal to zero.

TABLE 14—TEST OPERATING AND TEST CONDITION TOLERANCES FOR CYCLIC HEATING MODE TESTS.

	Test operating tolerance [1]	Test condition tolerance [2]
Indoor entering dry-bulb temperature, [3] °F	2.0	0.5
Indoor entering wet-bulb temperature, [3] °F	1.0	
Outdoor entering dry-bulb temperature, [3] °F	2.0	0.5
Outdoor entering wet-bulb temperature, [3] °F	2.0	1.0
External resistance to air-flow, [3] inches of water	0.05	
Airflow nozzle pressure difference or velocity pressure,[3] % of reading	2.0	[4] 2.0
Electrical voltage, [5] % of rdg	2.0	1.5

[1] See Definition 1.41.
[2] See Definition 1.40.
[3] Applies during the interval that air flows through the indoor (outdoor) coil except for the first 30 seconds after flow initiation. For units having a variable-speed indoor fan that ramps, the tolerances listed for the external resistance to airflow shall apply from 30 seconds after achieving full speed until ramp down begins.
[4] The test condition shall be the average nozzle pressure difference or velocity pressure measured during the steady-state test conducted at the same test conditions.
[5] Applies during the interval that at least one of the following—the compressor, the outdoor fan, or, if applicable, the indoor fan—are operating, except for the first 30 seconds after compressor start-up.

3.9 Test procedures for Frost Accumulation heating mode tests (the H2, $H2_2$, $H2_V$, and $H2_1$ Tests). a. Confirm that the defrost controls of the heat pump are set as specified in section 2.2.1. Operate the test room reconditioning apparatus and the heat pump for at least 30 minutes at the specified section 3.6 test conditions before starting the "preliminary" test period. The preliminary test period must immediately precede the "official" test period, which is the heating and defrost interval over which data are collected for evaluating average space heating capacity and average electrical power consumption.

b. For heat pumps containing defrost controls which are likely to cause defrosts at intervals less than one hour, the preliminary test period starts at the termination of an automatic defrost cycle and ends at the termination of the next occurring automatic defrost cycle. For heat pumps containing defrost controls which are likely to cause defrosts at intervals exceeding one hour, the preliminary test period must consist of a heating interval lasting at least one hour followed by a defrost cycle that is either manually or automatically initiated. In all cases, the heat pump's own controls must govern when a defrost cycle terminates.

c. The official test period begins when the preliminary test period ends, at defrost termination. The official test period ends at the termination of the next occurring automatic defrost cycle. When testing a heat pump that uses a time-adaptive defrost control system (see Definition 1.42), however, manually initiate the defrost cycle that ends the official test period at the instant indicated by instructions provided by the manufacturer. If the heat pump has not undergone a defrost after 6 hours, immediately conclude the test and use the results from the full 6-hour period to calculate the average space heating capacity and average electrical power consumption.

For heat pumps that turn the indoor fan off during the defrost cycle, take steps to cease forced airflow through the indoor coil and block the outlet duct whenever the heat pump's controls cycle off the indoor fan. If it is installed, use the outlet damper box described in section 2.5.4.1 to affect the blocked outlet duct.

d. Defrost termination occurs when the controls of the heat pump actuate the first change in converting from defrost operation to normal heating operation. Defrost initiation occurs when the controls of the heat pump first alter its normal heating operation in order to eliminate possible accumulations of frost on the outdoor coil.

e. To constitute a valid Frost Accumulation test, satisfy the test tolerances specified in Table 15 during both the preliminary and official test periods. As noted in Table 15, test operating tolerances are specified for two sub-intervals: (1) When heating, except for the first 10 minutes after the termination of a defrost cycle (Sub-interval H, as described in Table 15) and (2) when defrosting, plus these same first 10 minutes after defrost termination (Sub-interval D, as described in Table 15). Evaluate compliance with Table 15 test condition tolerances and the majority of the test operating tolerances using the averages from measurements recorded only during Sub-interval H. Continuously record the dry bulb temperature of the air entering the indoor coil, and the dry bulb temperature and water vapor content of the air entering the outdoor coil. Sample the remaining parameters listed in Table 15 at equal intervals that span 10 minutes or less.

f. For the official test period, collect and use the following data to calculate average space heating capacity and electrical power. During heating and defrosting intervals when the controls of the heat pump have the indoor fan on, continuously record the dry-bulb temperature of the air entering (as noted above) and leaving the indoor coil. If using a thermopile, continuously record the difference between the leaving and entering dry-bulb temperatures during the interval(s) that air flows through the indoor coil. For heat pumps tested without an indoor fan installed, determine the corresponding cumulative time (in hours) of indoor coil airflow,

$\Delta\tau_a$. Sample measurements used in calculating the air volume rate (refer to sections 7.7.2.1 and 7.7.2.2 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22)) at equal intervals that span 10 minutes or less. (Note: In the first printing of ASHRAE Standard 37–2005, the second IP equation for Q_{mi} should read: .) Record the electrical energy consumed, expressed in watt-hours, from defrost termination to defrost termination, $e_{DEF}^k(35)$, as well as the corresponding elapsed time in hours, $\Delta\tau_{FR}$.

TABLE 15—TEST OPERATING AND TEST CONDITION TOLERANCES FOR FROST ACCUMULATION HEATING MODE TESTS.

	Test operating tolerance [1]		Test condition tolerance [2]
	Sub-interval H [3]	Sub-interval D [4]	Sub-interval H [3]
Indoor entering dry-bulb temperature, °F	2.0	[5] 4.0	0.5
Indoor entering wet-bulb temperature, °F	1.0		
Outdoor entering dry-bulb temperature, °F	2.0	10.0	1.0
Outdoor entering wet-bulb temperature, °F	1.5		0.5
External resistance to airflow, inches of water	0.05		0.02 [6]
Electrical voltage, % of rdg	2.0		1.5

[1] See Definition 1.41.
[2] See Definition 1.40.
[3] Applies when the heat pump is in the heating mode, except for the first 10 minutes after termination of a defrost cycle.
[4] Applies during a defrost cycle and during the first 10 minutes after the termination of a defrost cycle when the heat pump is operating in the heating mode.
[5] For heat pumps that turn off the indoor fan during the defrost cycle, the noted tolerance only applies during the 10 minute interval that follows defrost termination.
[6] Only applies when testing non-ducted heat pumps.

3.9.1 Average space heating capacity and electrical power calculations. a. Evaluate average space heating capacity, $\dot{Q}_h^k(35)$, when expressed in units of Btu per hour, using:

$$\dot{Q}_h^k(35) = \frac{60 \cdot \overline{\dot{V}} \cdot C_{p,a} \cdot \Gamma}{\Delta\tau_{FR}\left[v_n' \cdot (1 + W_n)\right]} = \frac{60 \cdot \overline{\dot{V}} \cdot C_{p,a} \cdot \Gamma}{\Delta\tau_{FR} \cdot v_n}$$

where,

$\overline{\dot{V}}$ = the average indoor air volume rate measured during Sub-interval H, cfm.

$C_{p,a} = 0.24 + 0.444 \cdot W_n$, the constant pressure specific heat of the air-water vapor mixture that flows through the indoor coil and is expressed on a dry air basis, Btu / lbm_{da} · °F.

v_n' = specific volume of the air-water vapor mixture at the nozzle, ft³ / lbm_{mx}.

W_n = humidity ratio of the air-water vapor mixture at the nozzle, lbm of water vapor per lbm of dry air.

$\Delta\tau_{FR} = \tau_2 - \tau_1$, the elapsed time from defrost termination to defrost termination, hr.

$$\Gamma = \int_{\tau_1}^{\tau_2} \left[T_{a2}(\tau) - T_{a1}(\tau)\right] d\tau, \ \text{hr} \cdot {}^\circ\text{F}.$$

$T_{a1}(\tau)$ = dry bulb temperature of the air entering the indoor coil at elapsed time τ, °F; only recorded when indoor coil airflow occurs; assigned the value of zero during periods (if any) where the indoor fan cycles off.

$T_{a2}(\tau)$ = dry bulb temperature of the air leaving the indoor coil at elapsed time τ, °F; only recorded when indoor coil airflow occurs; assigned the value of zero during periods (if any) where the indoor fan cycles off.

τ_1 = the elapsed time when the defrost termination occurs that begins the official test period, hr.

τ_2 = the elapsed time when the next automatically occurring defrost termination occurs, thus ending the official test period, hr.

v_n = specific volume of the dry air portion of the mixture evaluated at the dry-bulb temperature, vapor content, and barometric pressure existing at the nozzle, ft³ per lbm of dry air.

To account for the effect of duct losses between the outlet of the indoor unit and the section 2.5.4 dry-bulb temperature grid, adjust $\dot{Q}_h^k(35)$ in accordance with section 7.3.4.3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22).

b. Evaluate average electrical power, $\dot{E}_h^k(35)$, when expressed in units of watts, using:

$$\dot{E}_h^k(35) = \frac{e_{def}(35)}{\Delta\tau_{FR}}.$$

For heat pumps tested without an indoor fan installed, increase $\dot{Q}_h^k(35)$ by,

$$\frac{1250\ \text{Btu/h}}{1000\ \text{scfm}} \cdot \overline{\dot{V}}_s \cdot \frac{\Delta\tau_a}{\Delta\tau_{FR}},$$

and increase $\dot{E}_h^k(35)$ by,

$$\frac{365\ \text{W}}{1000\ \text{scfm}} \cdot \overline{\dot{V}}_s \cdot \frac{\Delta\tau_a}{\Delta\tau_{FR}},$$

where $\overline{\dot{V}}_s$ is the average indoor air volume rate measured during the Frost Accumulation heating mode test and is expressed in units of cubic feet per minute of standard air (scfm).

c. For heat pumps having a constant-air-volume-rate indoor fan, the five additional steps listed below are required if the average of the external static pressures measured during sub-Interval H exceeds the applicable section 3.1.4.4, 3.1.4.5, or 3.1.4.6 minimum (or targeted) external static pressure (ΔP_{min}) by 0.03 inches of water or more:

1. Measure the average power consumption of the indoor fan motor ($\dot{E}_{fan,1}$) and record the corresponding external static pressure (ΔP_1) during or immediately following the Frost Accumulation heating mode test. Make the measurement at a time when the heat pump is heating, except for the first 10 minutes after the termination of a defrost cycle.

2. After the Frost Accumulation heating mode test is completed and while maintaining the same test conditions, adjust the exhaust fan of the airflow measuring apparatus until the external static pressure increases to approximately $\Delta P_1 + (\Delta P_1 - \Delta P_{min})$.

3. After re-establishing steady readings for the fan motor power and external static pressure, determine average values for the indoor fan power ($\dot{E}_{fan,2}$) and the external static pressure (ΔP_2) by making measurements over a 5-minute interval.

4. Approximate the average power consumption of the indoor fan motor had the Frost Accumulation heating mode test been conducted at ΔP_{min} using linear extrapolation:

$$\dot{E}_{fan,min} = \frac{\dot{E}_{fan,2} - \dot{E}_{fan,1}}{\Delta P_2 - \Delta P_1}\left(\Delta P_{min} - \Delta P_1\right) + \dot{E}_{fan,1}.$$

5. Decrease the total heating capacity, $\dot{Q}_h^k(35)$, by the quantity $[(\dot{E}_{fan,1} - \dot{E}_{fan,min}) \cdot (\Delta\tau_a/\Delta\tau_{FR})]$, when expressed on a Btu/h basis. Decrease the total electrical power, $E_h^k(35)$, by the same quantity, now expressed in watts.

3.9.2 Demand defrost credit. a. Assign the demand defrost credit, F_{def}, that is used in section 4.2 to the value of 1 in all cases except for heat pumps having a demand-defrost control system (Definition 1.21). For such qualifying heat pumps, evaluate F_{def} using,

$$F_{def} = 1 + 0.03 \cdot \left[1 - \frac{\Delta\tau_{def} - 1.5}{\Delta\tau_{max} - 1.5}\right],$$

where,

$\Delta\tau_{def}$ = the time between defrost terminations (in hours) or 1.5, whichever is greater.

$\Delta\tau_{max}$ = maximum time between defrosts as allowed by the controls (in hours) or 12, whichever is less.

b. For two-capacity heat pumps and for section 3.6.2 units, evaluate the above equation using the $\Delta\tau_{def}$ that applies based on the Frost Accumulation Test conducted at high capacity and/or at the Heating Full-loadAir Volume Rate. For variable-speed heat pumps, evaluate $\Delta\tau_{def}$ based on the required Frost Accumulation Test conducted at the intermediate compressor speed.

3.10 Test procedures for steady-state Low Temperature heating mode tests (the H3, $H3_2$, and $H3_1$ Tests). Except for the modifications noted in this section, conduct the Low Temperature heating mode test using the same approach as specified in section 3.7 for the Maximum and High Temperature tests. After satisfying the section 3.7 requirements for the pretest interval but before beginning to collect data to determine $\dot{Q}_h^k(17)$ and $\dot{E}_h^k(17)$, conduct a defrost cycle. This defrost cycle may be manually or automatically initiated. The defrost sequence must be terminated by the action of the heat pump's defrost controls. Begin the 30-minute data collection interval described in section 3.7, from which $\dot{Q}_h^k(17)$ and $\dot{E}_h^k(17)$ are determined, no sooner than 10 minutes after defrost termination. Defrosts should be prevented over the 30-minute data collection interval.

3.11 Additional requirements for the secondary test methods.

3.11.1 If using the Outdoor Air Enthalpy Method as the secondary test method. During the ''official'' test, the outdoor air-side test apparatus described in section 2.10.1 is connected to the outdoor unit. To help compensate for any effect that the addition of this test apparatus may have on the unit's performance, conduct a ''preliminary'' test where the outdoor air-side test apparatus is disconnected. Conduct a preliminary test prior to the first section 3.2 steady-state cooling mode test and prior to the first section 3.6 steady-state heating mode test. No other preliminary tests are required so long as the unit operates the outdoor fan during all cooling mode steady-state tests at the same speed and all heating mode steady-state tests at the same speed. If using more than one outdoor fan speed for the cooling mode steady-state tests, however, conduct a preliminary test prior to each cooling mode test where a different fan speed is first used. This same requirement applies for the heating mode tests.

3.11.1.1 If a preliminary test precedes the official test. a. The test conditions for the preliminary test are the same as specified for the official test. Connect the indoor air-side test apparatus to the indoor coil; disconnect the outdoor air-side test apparatus. Allow the test room reconditioning apparatus and the unit being tested to operate for at least one hour. After attaining equilibrium conditions, measure the following quantities at equal intervals that span 10 minutes or less:

1. The section 2.10.1 evaporator and condenser temperatures or pressures;

2. Parameters required according to the Indoor Air Enthalpy Method.

Continue these measurements until a 30-minute period (*e.g.*, four consecutive 10-minute samples) is obtained where the Table 7 or Table 13, whichever applies, test tolerances are satisfied.

b. After collecting 30 minutes of steady-state data, reconnect the outdoor air-side test apparatus to the unit. Adjust the exhaust fan of the outdoor airflow measuring apparatus until averages for the evaporator and condenser temperatures, or the saturated temperatures corresponding to the measured pressures, agree within ±0.5 °F of the averages achieved when the outdoor air-side test apparatus was disconnected. Calculate the averages for the reconnected case using five or more consecutive readings taken at one minute intervals. Make these consecutive readings after re-establishing equilibrium conditions and before initiating the official test.

3.11.1.2 If a preliminary test does not precede the official test. Connect the outdoor-side test apparatus to the unit. Adjust the exhaust fan of the outdoor airflow measuring apparatus to achieve the same external static pressure as measured during the prior preliminary test conducted with the unit operating in the same cooling or heating mode at the same outdoor fan speed.

3.11.1.3 Official test. a. Continue (preliminary test was conducted) or begin (no preliminary test) the official test by making measurements for both the Indoor and Outdoor Air Enthalpy Methods at equal intervals that span 10 minutes or less. Discontinue these measurement only after obtaining a 30-minute period where the specified test condition and test operating tolerances are satisfied. To constitute a valid official test:

(1) Achieve the energy balance specified in section 3.1.1; and,

(2) For cases where a preliminary test is conducted, the capacities determined using the Indoor Air Enthalpy Method from the official and preliminary test periods must agree within 2.0 percent.

b. For space cooling tests, calculate capacity from the outdoor air-enthalpy measurements as specified in sections 7.3.3.2 and 7.3.3.3 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22). Calculate heating capacity based on outdoor air-enthalpy measurements as specified in sections 7.3.4.2 and 7.3.3.4.3 of the same ASHRAE Standard. Adjust the outdoor-side capacity according to section 7.3.3.4 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22) to account for line losses when testing split systems. Use the outdoor unit fan power as measured during the official test and not the value measured during the preliminary test, as described in section 8.6.2 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22), when calculating the capacity.

3.11.2 If using the Compressor Calibration Method as the secondary test method.

a. Conduct separate calibration tests using a calorimeter to determine the refrigerant flow rate. Or for cases where the superheat of the refrigerant leaving the evaporator is less than 5 °F, use the calorimeter to measure total capacity rather than refrigerant flow rate. Conduct these calibration tests at the same test conditions as specified for the tests in this appendix. Operate the unit for at least one hour or until obtaining equilibrium conditions before collecting data that will be used in determining the average refrigerant flow rate or total capacity. Sample the data at equal intervals that span 10 minutes or less. Determine average flow rate or average capacity from data sampled over a 30-minute period where the Table 7 (cooling) or the Table 13 (heating) tolerances are satisfied. Otherwise, conduct the calibration tests according to ASHRAE Standard 23–05 (incorporated by reference, see §430.22), ASHRAE Standard 41.9–2000 (incorporated by reference, see §430.22), and section 7.4 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22).

b. Calculate space cooling and space heating capacities using the compressor calibration method measurements as specified in section 7.4.5 and 7.4.6 respectively, of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22).

b. Calculate space cooling and space heating capacities using the compressor calibration method measurements as specified in section 7.4.5 and 7.4.6 respectively, of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22).

3.11.3 If using the Refrigerant-Enthalpy Method as the secondary test method. Conduct this secondary method according to section 7.5 of ASHRAE Standard 37–2005 (incorporated by reference, see §430.22). Calculate space cooling and heating capacities using the refrigerant-enthalpy method measurements as specified in sections 7.5.4 and 7.5.5, respectively, of the same ASHRAE Standard.

3.12 Rounding of space conditioning capacities for reporting purposes.

a. When reporting rated capacities, round them off as follows:

1. For capacities less than 20,000 Btu/h, round to the nearest 100 Btu/h.

2. For capacities between 20,000 and 37,999 Btu/h, round to the nearest 200 Btu/h.

3. For capacities between 38,000 and 64,999 Btu/h, round to the nearest 500 Btu/h.

b. For the capacities used to perform the section 4 calculations, however, round only to the nearest integer.

4. CALCULATIONS OF SEASONAL PERFORMANCE DESCRIPTORS

4.1 Seasonal Energy Efficiency Ratio (SEER) Calculations. SEER must be calculated as follows: For equipment covered under sections 4.1.2, 4.1.3, and 4.1.4, evaluate the seasonal energy efficiency ratio,

$$\mathrm{SEER} = \frac{\sum_{j=1}^{8} q_c(T_j)}{\sum_{j=1}^{8} e_c(T_j)} = \frac{\sum_{j=1}^{8} \frac{q_c(T_j)}{N}}{\sum_{j=1}^{8} \frac{e_c(T_j)}{N}} \qquad (4.1\text{-}1)$$

where,

$$\frac{q_c(T_j)}{N} =$$

the ratio of the total space cooling provided during periods of the space cooling season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the cooling season (N), Btu/h.

$$\frac{e_c(T_j)}{N} =$$

the electrical energy consumed by the test unit during periods of the space cooling season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the cooling season (N), W.

T_j = the outdoor bin temperature, °F. Outdoor temperatures are grouped or ‘‘binned.’’ Use bins of 5 °F with the 8 cooling season bin temperatures being 67, 72, 77, 82, 87, 92, 97, and 102 °F.

j = the bin number. For cooling season calculations, j ranges from 1 to 8.

Additionally, for sections 4.1.2, 4.1.3, and 4.1.4, use a building cooling load, $BL(T_j)$. When referenced, evaluate $BL(T_j)$ for cooling using,

$$BL(T_j) = \frac{(T_j - 65)}{95 - 65} \cdot \frac{\dot{Q}_c^{k=2}(95)}{1.1} \qquad (4.1\text{-}2)$$

where,

$\dot{Q}_c^{k=2}(95)$ = the space cooling capacity determined from the A_2 Test and calculated as specified in section 3.3, Btu/h.

1.1 = sizing factor, dimensionless.

The temperatures 95 °F and 65 °F in the building load equation represent the selected outdoor design temperature and the zero-load base temperature, respectively.

4.1.1 SEER calculations for an air conditioner or heat pump having a single-speed compressor that was tested with a fixed-speed indoor fan installed, a constant-air-volume-rate indoor fan installed, or with no indoor fan installed. a. Evaluate the seasonal energy efficiency ratio, expressed in units of Btu/watt-hour, using:

$SEER = PLF(0.5) \cdot EER_B$

where,

$$EER_B = \frac{\dot{Q}_c(82)}{\dot{E}_c(82)},$$

the energy efficiency ratio determined from the B Test described in sections 3.2.1, 3.1.4.1, and 3.3, Btu/h per watt.

$PLF(0.5) = 1 - 0.5 \cdot C_D^c$, the part-load performance factor evaluated at a cooling load factor of 0.5, dimensionless.

b. Refer to section 3.3 regarding the definition and calculation of $\dot{Q}_c(82)$ and $\dot{E}_c(82)$. If the optional tests described in section 3.2.1 are not conducted, set the cooling mode cyclic degradation coefficient, C_D^c, to the default value specified in section 3.5.3. If these optional tests are conducted, set C_D^c to the lower of:

1. The value calculated as per section 3.5.3; or

2. The section 3.5.3 default value of 0.25.

4.1.2 SEER calculations for an air conditioner or heat pump having a single-speed compressor and a variable-speed variable-air-volume-rate indoor fan.

4.1.2.1 Units covered by section 3.2.2.1 where indoor fan capacity modulation correlates with the outdoor dry bulb temperature. The manufacturer must provide information on how the indoor air volume rate or the indoor fan speed varies over the outdoor temperature range of 67 °F to 102 °F. Calculate SEER using Equation 4.1–1. Evaluate the quantity $q_c(T_j)/N$ in Equation 4.1–1 using,

$$\frac{q_c(T_j)}{N} = X(T_j) \cdot \dot{Q}_c(T_j) \cdot \frac{n_j}{N} \qquad (4.1.2\text{-}1)$$

where,

$$X(T_j) = \begin{Bmatrix} BL(T_j)/\dot{Q}_c(T_j) \\ \text{or} \\ 1 \end{Bmatrix};$$

whichever is less; the cooling mode load factor for temperature bin j, dimensionless.

$\dot{Q}_c(T_j)$ = the space cooling capacity of the test unit when operating at outdoor temperature, T_j, Btu/h.

n_j/N = fractional bin hours for the cooling season; the ratio of the number of hours during the cooling season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the cooling season, dimensionless.

a. For the space cooling season, assign n_j/N as specified in Table 16. Use Equation 4.1–2 to calculate the building load, $BL(T_j)$. Evaluate $\dot{Q}_c(T_j)$ using,

$$\dot{Q}_c(T_j) = \dot{Q}_c^{k=1}(T_j) + \frac{\dot{Q}_c^{k=2}(T_j) - \dot{Q}_c^{k=1}(T_j)}{FP_c^{k=2} - FP_c^{k=1}} \cdot \left[FP_c(T_j) - FP_c^{k=1}\right] \qquad (4.1.2\text{-}2)$$

where,

$$\dot{Q}_c^{k=1}(T_j) = \dot{Q}_c^{k=1}(82) + \frac{\dot{Q}_c^{k=1}(95) - \dot{Q}_c^{k=1}(82)}{95 - 82} \cdot (T_j - 82),$$

the space cooling capacity of the test unit at outdoor temperature T_j if operated at the Cooling Minimum Air Volume Rate, Btu/h.

$$\dot{Q}_c^{k=2}\left(T_j\right) = \dot{Q}_c^{k=2}(82) + \frac{\dot{Q}_c^{k=2}(95) - \dot{Q}_c^{k=2}(82)}{95 - 82} \cdot \left(T_j - 82\right),$$

the space cooling capacity of the test unit at outdoor temperature T_j if operated at the Cooling Full-load Air Volume Rate, Btu/h.

b. For units where indoor fan speed is the primary control variable, $FP_c^{k=1}$ denotes the fan speed used during the required A_1 and B_1 Tests (see section 3.2.2.1), $FP_c^{k=2}$ denotes the fan speed used during the required A_2 and B_2 Tests, and $FP_c(T_j)$ denotes the fan speed used by the unit when the outdoor temperature equals T_j. For units where indoor air volume rate is the primary control variable, the three FP_c's are similarly defined only now being expressed in terms of air volume rates rather than fan speeds. Refer to sections 3.2.2.1, 3.1.4 to 3.1.4.2, and 3.3 regarding the definitions and calculations of $\dot{Q}_c^{k=1}(82)$, $\dot{Q}_c^{k=1}(95)$, $\dot{Q}_c^{k=2}(82)$, and $\dot{Q}_c^{k=2}(95)$.

Calculate $e_c(T_j)/N$ in Equation 4.1–1 using,

$$\frac{e_c\left(T_j\right)}{N} = \frac{X\left(T_j\right) \cdot \dot{E}_c\left(T_j\right)}{PLF_j} \cdot \frac{n_j}{N} \qquad (4.1.2\text{-}3)$$

where,

$PLF_j = 1 - C_D^c \cdot [1 - X(T_j)]$, the part load factor, dimensionless.

$\dot{E}_c(T_j)$ = the electrical power consumption of the test unit when operating at outdoor temperature T_j, W.

c. The quantities $X(T_j)$ and n_j /N are the same quantities as used in Equation 4.1.2–1. If the optional tests described in section 3.2.2.1 and Table 4 are not conducted, set the cooling mode cyclic degradation coefficient, C_D^c, to the default value specified in section 3.5.3. If these optional tests are conducted, set C_D^c to the lower of:

1. The value calculated as per section 3.5.3; or

2 .The section 3.5.3 default value of 0.25.

d. Evaluate $\dot{E}_c(T_j)$ using,

$$\dot{E}_c\left(T_j\right) = \dot{E}_c^{k=1}\left(T_j\right) + \frac{\dot{E}_c^{k=2}\left(T_j\right) - \dot{E}_c^{k=1}\left(T_j\right)}{FP_c^{k=2} - FP_c^{k=1}} \cdot \left[FP_c\left(T_j\right) - FP_c^{k=1}\right] \qquad (4.1.2\text{-}4)$$

where

$$\dot{E}_c^{k=1}\left(T_j\right) = \dot{E}_c^{k=1}(82) + \frac{\dot{E}_c^{k=1}(95) - \dot{E}_c^{k=1}(82)}{95 - 82} \cdot \left(T_j - 82\right),$$

the electrical power consumption of the test unit at outdoor temperature T_j if operated at the Cooling Minimum Air Volume Rate, W.

$$\dot{E}_c^{k=2}\left(T_j\right) = \dot{E}_c^{k=2}(82) + \frac{\dot{E}_c^{k=2}(95) - \dot{E}_c^{k=2}(82)}{95 - 82} \cdot \left(T_j - 82\right),$$

the electrical power consumption of the test unit at outdoor temperature T_j if operated at the Cooling Full-load Air Volume Rate, W.

e. The parameters $FP_c^{k=1}$, and $FP_c^{k=2}$, and $FP_c(T_j)$ are the same quantities that are used when evaluating Equation 4.1.2–2. Refer to sections 3.2.2.1, 3.1.4 to 3.1.4.2, and 3.3 regarding the definitions and calculations of $\dot{E}_c^{k=1}(82)$, $\dot{E}_c^{k=1}(95)$, $\dot{E}_c^{k=2}(82)$, and $\dot{E}_c^{k=2}(95)$.

4.1.2.2 Units covered by section 3.2.2.2 where indoor fan capacity modulation is used to adjust the sensible to total cooling capacity ratio. Calculate SEER as specified in section 4.1.1.

4.1.3 SEER calculations for an air conditioner or heat pump having a two-capacity compressor. Calculate SEER using Equation 4.1–1. Evaluate the space cooling capacity, $\dot{Q}_c^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=1}(T_j)$, of the test unit when operating at low compressor capacity and outdoor temperature T_j using,

$$\dot{Q}_c^{k=1}(T_j) = \dot{Q}_c^{k=1}(67) + \frac{\dot{Q}_c^{k=1}(82) - \dot{Q}_c^{k=1}(67)}{82-67} \cdot (T_j - 67) \qquad (4.1.3\text{-}1)$$

$$\dot{E}_c^{k=1}(T_j) = E_c^{k=1}(67) + \frac{E_c^{k=1}(82) - E_c^{k=1}(67)}{82-67} \cdot (T_j - 67) \qquad (4.1.3\text{-}2)$$

where $\dot{Q}_c^{k=1}(82)$ and $\dot{E}_c^{k=1}(82)$ are determined from the B_1 Test, $\dot{Q}_c^{k=1}(67)$ and $\dot{E}_c^{k=1}(67)$ are determined from the F_1 Test, and all four quantities are calculated as specified in section 3.3. Evaluate the space cooling capacity, $\dot{Q}_c^{k=2}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=2}(T_j)$, of the test unit when operating at high compressor capacity and outdoor temperature T_j using,

$$\dot{Q}_c^{k=2}(T_j) = \dot{Q}_c^{k=2}(82) + \frac{\dot{Q}_c^{k=2}(95) - \dot{Q}_c^{k=2}(82)}{95-82} \cdot (T_j - 82) \qquad (4.1.3\text{-}3)$$

$$\dot{E}_c^{k=2}(T_j) = \dot{E}_c^{k=2}(82) + \frac{\dot{E}_c^{k=2}(95) - \dot{E}_c^{k=2}(82)}{95-82} \cdot (T_j - 82) \qquad (4.1.3\text{-}4)$$

where $\dot{Q}_c^{k=2}(95)$ and $\dot{E}_c^{k=2}(95)$ are determined from the A_2 Test, $\dot{Q}_c^{k=2}(82)$, and $\dot{E}_c^{k=2}(82)$, are determined from the B_2 Test, and all are calculated as specified in section 3.3.

The calculation of Equation 4.1–1 quantities $q_c(T_j)/N$ and $e_c(T_j)/N$ differs depending on whether the test unit would operate at low capacity (section 4.1.3.1), cycle between low and high capacity (section 4.1.3.2), or operate at high capacity (sections 4.1.3.3 and 4.1.3.4) in responding to the building load. For units that lock out low capacity operation at higher outdoor temperatures, the manufacturer must supply information regarding this temperature so that the appropriate equations are used. Use Equation 4.1–2 to calculate the building load, $BL(T_j)$, for each temperature bin.

4.1.3.1 Steady-state space cooling capacity at low compressor capacity is greater than or equal to the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) \geq BL(T_j)$.

$$\frac{q_c(T_j)}{N} = X^{k=1}(T_j) \cdot \dot{Q}_c^{k=1}(T_j) \cdot \frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = \frac{X^{k=1}(T_j) \cdot \dot{E}_c^{k=1}(T_j)}{PLF_j} \cdot \frac{n_j}{N}$$

where,

$X^{k=1}(T_j) = BL(T_j)/\dot{Q}_c^{k=1}(T_j)$, the cooling mode low capacity load factor for temperature bin j, dimensionless.

$PLF_j = 1 - C_D^c \cdot [1 - X^{k=1}(T_j)]$, the part load factor, dimensionless.

$$\frac{n_j}{N} =$$

fractional bin hours for the cooling season; the ratio of the number of hours during the cooling season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the cooling season, dimensionless.

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 16. Use Equations 4.1.3–1 and 4.1.3–2, respectively, to evaluate $\dot{Q}_c^{k=1}(T_j)$ and $\dot{E}_c^{k=1}(T_j)$. If the optional tests described in section 3.2.3 and Table 5 are not conducted, set the cooling mode cyclic degradation coefficient, C_D^c, to the default value specified in section 3.5.3. If these optional tests are conducted, set C_D^c to the lower of:

a. The value calculated according to section 3.5.3; or

b. The section 3.5.3 default value of 0.25.

TABLE 16—DISTRIBUTION OF FRACTIONAL HOURS WITHIN COOLING SEASON TEMPERATURE BINS

Bin number, j	Bin temperature range °F	Representative temperature for bin °F	Fraction of of total temperature bin hours, n_j/N
1	65–69	67	0.214
2	70–74	72	0.231
3	75–79	77	0.216
4	80–84	82	0.161
5	85–89	87	0.104
6	90–94	92	0.052
7	95–99	97	0.018
8	100–104	102	0.004

4.1.3.2 Unit alternates between high (k=2) and low (k=1) compressor capacity to satisfy the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

$$\frac{q_c(T_j)}{N} = \left[X^{k=1}(T_j)\cdot\dot{Q}_c^{k=1}(T_j) + X^{k=2}(T_j)\cdot\dot{Q}_c^{k=2}(T_j)\right]\cdot\frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = \left[X^{k=1}(T_j)\cdot\dot{E}_c^{k=1}(T_j) + X^{k=2}(T_j)\cdot\dot{E}_c^{k=2}(T_j)\right]\cdot\frac{n_j}{N}$$

where,

$$X^{k=1}(T_j) = \frac{\dot{Q}_c^{k=2}(T_j) - BL(T_j)}{\dot{Q}_c^{k=2}(T_j) - \dot{Q}_c^{k=1}(T_j)},$$

the cooling mode, low capacity load factor for temperature bin j, dimensionless.

$X^{k=2}(T_j) = 1 - X^{k=1}(T_j)$, the cooling mode, high capacity load factor for temperature bin j, dimensionless.

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 16. Use Equations 4.1.3–1 and 4.1.3–2, respectively, to evaluate $\dot{Q}_c^{k=1}(T_j)$ and $\dot{E}_c^{k=1}(T_j)$. Use Equations 4.1.3–3 and 4.1.3–4, respectively, to evaluate $\dot{Q}_c^{k=2}(T_j)$ and $\dot{E}_c^{k=2}(T_j)$.

4.1.3.3 Unit only operates at high (k=2) compressor capacity at temperature T_j and its capacity is greater than the building cooling load, $BL(T_j) < \dot{Q}_c^{k=2}(T_j)$. This section applies to units that lock out low compressor capacity operation at higher outdoor temperatures.

$$\frac{q_c(T_j)}{N} = X^{k=2}(T_j)\cdot\dot{Q}_c^{k=2}(T_j)\cdot\frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = \frac{X^{k=2}(T_j)\cdot\dot{E}_c^{k=2}(T_j)}{PLF_j}\cdot\frac{n_j}{N}$$

where,

$X^{k=2}(T_j) = BL(T_j)/\dot{Q}_c^{k=2}(T_j)$, the cooling mode high capacity load factor for temperature bin j, dimensionless.

$$PLF_j = 1 - C_D^c(k=2)\cdot\left[1 - X^{k=2}(T_j)\right],$$

the part load factor, dimensionless.

Obtain the fraction bin hours for the cooling season,

$$\frac{n_j}{N},$$

from Table 16. Use Equations 4.1.3–3 and 4.1.3–4, respectively, to evaluate $\dot{Q}_c^{k=2}(T_j)$ and $\dot{E}_c^{k=2}(T_j)$. If the optional C_2 and D_2 Tests described in section 3.2.3 and Table 5 are not conducted, set C_D^c (k=2) equal to the default value specified in section 3.5.3. If these optional tests are conducted, set C_D^c (k=2) to the lower of:

a. the C_D^c (k=2) value calculated as per section 3.5.3; or

b. the section 3.5.3 default value for C_D^c (k=2) .

4.1.3.4 Unit must operate continuously at high (k=2) compressor capacity at temperature T_j, $BL(T_j) \geq \dot{Q}_c^{k=2}(T_j)$.

$$\frac{q_c(T_j)}{N} = \dot{Q}_c^{k=2}(T_j) \cdot \frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = \dot{E}_c^{k=2}(T_j) \cdot \frac{n_j}{N}.$$

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 16. Use Equations 4.1.3–3 and 4.1.3–4, respectively, to evaluate $\dot{Q}_c^{k=2}(T_j)$ and $\dot{E}_c^{k=2}(T_j)$.

4.1.4 SEER calculations for an air conditioner or heat pump having a variable-speed compressor. Calculate SEER using Equation 4.1–1. Evaluate the space cooling capacity, $\dot{Q}_c^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=1}(T_j)$, of the test unit when operating at minimum compressor speed and outdoor temperature T_j. Use,

$$\dot{Q}_c^{k=1}(T_j) = \dot{Q}_c^{k=1}(67) + \frac{\dot{Q}_c^{k=1}(82) - \dot{Q}_c^{k=1}(67)}{82-67} \cdot (T_j - 67) \qquad (4.1.4\text{-}1)$$

$$\dot{E}_c^{k=1}(T_j) = \dot{E}_c^{k=1}(67) + \frac{\dot{E}_c^{k=1}(82) - \dot{E}_c^{k=1}(67)}{82-67} \cdot (T_j - 67) \qquad (4.1.4\text{-}2)$$

where $\dot{Q}_c^{k=1}(82)$ and $\dot{E}_c^{k=1}(82)$ are determined from the B_1 Test, $\dot{Q}_c^{k=1}(67)$ and $\dot{E}_c^{k=1}(67)$ are determined from the F1 Test, and all four quantities are calculated as specified in section 3.3. Evaluate the space cooling capacity, $\dot{Q}_c^{k=2}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=2}(T_j)$, of the test unit when operating at maximum compressor speed and outdoor temperature T_j. Use Equations 4.1.3–3 and 4.1.3–4, respectively, where $\dot{Q}_c^{k=2}(95)$ and $\dot{E}_c^{k=2}(95)$ are determined from the A_2 Test, $\dot{Q}_c^{k=2}(82)$ and $\dot{E}_c^{k=2}(82)$ are determined from the B_2 Test, and all four quantities are calculated as specified in section 3.3. Calculate the space cooling capacity, $\dot{Q}_c^{k=v}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=v}(T_j)$, of the test unit when operating at outdoor temperature T_j and the intermediate compressor speed used during the section 3.2.4 (and Table 6) E_V Test using,

$$M_Q = \left[\frac{\dot{Q}_c^{k=1}(82) - \dot{Q}_c^{k=1}(67)}{82-67} \cdot (1 - N_Q)\right] + \left[N_Q \cdot \frac{\dot{Q}_c^{k=2}(95) - \dot{Q}_c^{k=2}(82)}{95-82}\right]$$

$$M_E = \left[\frac{\dot{E}_c^{k=1}(82) - \dot{E}_c^{k=1}(67)}{82-67} \cdot (1 - N_E)\right] + \left[N_E \cdot \frac{\dot{E}_c^{k=2}(95) - \dot{E}_c^{k=2}(82)}{95-82}\right]$$

4.1.4.1 Steady-state space cooling capacity when operating at minimum compressor speed is greater than or equal to the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) \geq BL(T_j)$.

$$\frac{q_c(T_j)}{N} = X^{k=1}(T_j) \cdot \dot{Q}_c^{k=1}(T_j) \cdot \frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = \frac{X^{k=1}(T_j) \cdot \dot{E}_c^{k=1}(T_j)}{PLF_J} \cdot \frac{n_j}{N}$$

where,

$X^{k=1}(T_j) = BL(T_j) / \dot{Q}_c^{k=1}(T_j)$, the cooling mode minimum speed load factor for temperature bin j, dimensionless.

$PLF_j = 1 - C_D^c \cdot [1 - X^{k=1}(T_j)]$, the part load factor, dimensionless.

n_j/N = fractional bin hours for the cooling season; the ratio of the number of hours during the cooling season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the cooling season, dimensionless.

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 16. Use Equations 4.1.3–1 and 4.1.3–2, respectively, to evaluate $\dot{Q}_c^{k=l}(T_j)$ and $\dot{E}_c^{k=l}(T_j)$. If the optional tests described in section 3.2.4 and Table 6 are not conducted, set the cooling mode cyclic degradation coefficient, C_D^c, to the default value specified in section 3.5.3. If these optional tests are conducted, set C_D^c to the lower of:

a. The value calculated according to section 3.5.3; or

b. The section 3.5.3 default value of 0.25.

4.1.4.2 Unit operates at an intermediate compressor speed (k=i) in order to match the building cooling load at temperature $T_j, \dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

$$\frac{q_c(T_j)}{N} = \dot{Q}_c^{k=i}(T_j) \cdot \frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = \dot{E}_c^{k=i}(T_j) \cdot \frac{n_j}{N}$$

where,

$\dot{Q}_c^{k=i}(T_j) = BL(T_j)$, the space cooling capacity delivered by the unit in matching the building load at temperature T_j, Btu/h. The matching occurs with the unit operating at compressor speed k = i.

$$\dot{E}_c^{k=i}(T_j) = \frac{\dot{Q}_c^{k=i}(T_j)}{EER^{k=i}(T_j)},$$

the electrical power input required by the test unit when operating at a compressor speed of k = i and temperature T_j, W.

$EER^{k=i}(T_j)$ = the steady-state energy efficiency ratio of the test unit when operating at a compressor speed of k = i and temperature T_j, Btu/h per W.

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 16. For each temperature bin where the unit operates at an intermediate compressor speed, determine the energy efficiency ratio $EER^{k=i}(T_j)$ using,

$EER^{k=i}(T_j) = A + B \cdot T_j + C \cdot T_j^2$.

For each unit, determine the coefficients A, B, and C by conducting the following calculations once:

$$D = \frac{T_2^2 - T_1^2}{T_v^2 - T_1^2}$$

$$B = \frac{EER^{k=1}(T_1) - EER^{k=2}(T_2) - D \cdot \left[EER^{k=1}(T_1) - EER^{k=v}(T_v)\right]}{T_1 - T_2 - D \cdot (T_1 - T_v)}$$

$$C = \frac{EER^{k=1}(T_1) - EER^{k=2}(T_2) - B \cdot (T_1 - T_2)}{T_1^2 - T_2^2}$$

$$A = EER^{k=2}(T_2) - B \cdot T_2 - C \cdot T_2^2$$

where,

T_1 = the outdoor temperature at which the unit, when operating at minimum compressor speed, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=l}(T_l) = BL(T_1)$), °F. Determine T_1 by equating Equations 4.1.3–1 and 4.1–2 and solving for outdoor temperature. T_v = the outdoor temperature at which the unit, when operating at the intermediate compressor speed used during the section 3.2.4 E_V Test, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=v}(T_v) = BL(T_v)$), °F. Determine T_v by equating Equations 4.1.4–1 and 4.1–2 and solving for outdoor temperature.

T_2 = the outdoor temperature at which the unit, when operating at maximum compressor speed, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=2}(T_2) = BL(T_2)$), °F. Determine T_2 by equating Equations 4.1.3–3 and 4.1–2 and solving for outdoor temperature.

$$EER^{k=1}(T_1) = \frac{\dot{Q}_c^{k=1}(T_1)\ [\text{Eqn. 4.1.4-1, substituting } T_1 \text{ for } T_j]}{\dot{E}_c^{k=1}(T_1)\ [\text{Eqn. 4.1.4-2, substituting } T_1 \text{ for } T_j]}, \text{ Btu/h per W.}$$

$$EER^{k=v}(T_v) = \frac{\dot{Q}_c^{k=v}(T_v)\ [\text{Eqn. 4.1.4-3, substituting } T_v \text{ for } T_j]}{\dot{E}_c^{k=v}(T_v)\ [\text{Eqn. 4.1.4-4, substituting } T_v \text{ for } T_j]}, \text{ Btu/h per W.}$$

$$EER^{k=2}(T_2) = \frac{\dot{Q}_c^{k=2}(T_2)\ [\text{Eqn. 4.1.3-3, substituting } T_2 \text{ for } T_j]}{\dot{E}_c^{k=2}(T_2)\ [\text{Eqn. 4.1.3-4, substituting } T_2 \text{ for } T_j]}, \text{ Btu/h per W.}$$

4.1.4.3 Unit must operate continuously at maximum (k=2) compressor speed at temperature Tj, $BL(T_j) \geq \dot{Q}_c^{k=2}(T_j)$. Evaluate the Equation 4.1–1 quantities

$$\frac{q_c(T_j)}{N} \text{ and } \frac{e_c(T_j)}{N}$$

as specified in section 4.1.3.4 with the understanding that $\dot{Q}_c^{k=2}(T_j)$ and $\dot{E}_c^{k=2}(T_j)$ correspond to maximum compressor speed operation and are derived from the results of the tests specified in section 3.2.4.

4.2 Heating Seasonal Performance Factor (HSPF) Calculations. Unless an approved alternative rating method is used, as set forth in 10 CFR 430.24(m), subpart B, HSPF must be calculated as follows: Six generalized climatic regions are depicted in Figure 2 and otherwise defined in Table 17. For each of these regions and for each applicable standardized design heating requirement, evaluate the heating seasonal performance factor using,

$$HSPF = \frac{\sum_j^J n_j \cdot BL(T_j)}{\sum_j^J e_h(T_j) + \sum_j^J RH(T_j)} \cdot F_{def} = \frac{\sum_j^J \left[\frac{n_j}{N} \cdot BL(T_j)\right]}{\sum_j^J \frac{e_h(T_j)}{N} + \sum_j^J \frac{RH(T_j)}{N}} \cdot F_{def} \qquad (4.2\text{-}1)$$

where,

$e_h(T_j)/N$=

The ratio of the electrical energy consumed by the heat pump during periods of the space heating season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the heating season (N), W. For heat pumps having a heat comfort controller, this ratio may also include electrical energy used by resistive elements to maintain a minimum air delivery temperature (see 4.2.5).

$RH(T_j)/N$=

The ratio of the electrical energy used for resistive space heating during periods when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the heating season (N), W. Except as noted in section 4.2.5, resistive space heating is modeled as being used to meet that portion of the building load that the heat pump does not meet because of insufficient capacity or because the heat pump automatically turns off at the lowest outdoor temperatures. For heat pumps having a heat comfort controller, all or part of the electrical energy used by resistive heaters at a particular bin temperature may be reflected in $e_h(T_j)/N$ (see 4.2.5).

T_j = the outdoor bin temperature, °F. Outdoor temperatures are ''binned'' such that calculations are only performed based one temperature within the bin. Bins of 5 °F are used.

n_j/N=

Fractional bin hours for the heating season; the ratio of the number of hours during the heating season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the heating season, dimensionless. Obtain n_j/N values from Table 17.

j = the bin number, dimensionless.

J = for each generalized climatic region, the total number of temperature bins, dimensionless. Referring to Table 17, J is the highest bin number (j) having a nonzero entry for the fractional bin hours for the generalized climatic region of interest.

F_{def} = the demand defrost credit described in section 3.9.2, dimensionless.

$BL(T_j)$ = the building space conditioning load corresponding to an outdoor temperature of T_j; the heating season building load also depends on the generalized climatic region's outdoor design temperature and the design heating requirement, Btu/h.

TABLE 17—GENERALIZED CLIMATIC REGION INFORMATION

Region Number		I	II	III	IV	V	VI
Heating Load Hours, HLH		750	1250	1750	2250	2750	*2750
Outdoor Design Temperature, T_{OD}		37	27	17	5	−10	30
j	T_j (°F)	Fractional Bin Hours, n_j/N					
1	62	.291	.215	.153	.132	.106	.113
2	57	.239	.189	.142	.111	.092	.206
3	52	.194	.163	.138	.103	.086	.215
4	47	.129	.143	.137	.093	.076	.204
5	42	.081	.112	.135	.100	.078	.141
6	37	.041	.088	.118	.109	.087	.076
7	32	.019	.056	.092	.126	.102	.034
8	27	.005	.024	.047	.087	.094	.008
9	22	.001	.008	.021	.055	.074	.003
10	17	0	.002	.009	.036	.055	0
11	12	0	0	.005	.026	.047	0
12	7	0	0	.002	.013	.038	0
13	2	0	0	.001	.006	.029	0
14	−3	0	0	0	.002	.018	0
15	−8	0	0	0	.001	.010	0
16	−13	0	0	0	0	.005	0
17	−18	0	0	0	0	.002	0
18	−23	0	0	0	0	.001	0

*Pacific Coast Region.

Evaluate the building heating load using

$$BL(T_j) = \frac{(65 - T_j)}{65 - T_{OD}} \cdot C \cdot DHR \qquad (4.2\text{-}2)$$

where,

T_{OD} = the outdoor design temperature, °F. An outdoor design temperature is specified for each generalized climatic region in Table 17.

C = 0.77, a correction factor which tends to improve the agreement between calculated and measured building loads, dimensionless.

DHR = the design heating requirement (see Definition 1.22), Btu/h.

Calculate the minimum and maximum design heating requirements for each generalized climatic region as follows:

$$DHR_{min} = \left\{ \begin{array}{ll} \dot{Q}_h^k(47) \cdot \left[\dfrac{65 - T_{OD}}{60}\right], & \text{for Regions I, II, III, IV, \& VI} \\ \dot{Q}_h^k(47), & \text{for Region V} \end{array} \right\} \text{Rounded to the nearest standardized DHR given in Table 18.}$$

and

$$DHR_{max} = \begin{cases} 2 \cdot \dot{Q}_h^k(47) \cdot \left[\dfrac{65 - T_{OD}}{60}\right], & \text{for Regions I, II, III, IV, \& VI} \\ 2.2 \cdot \dot{Q}_h^k(47), & \text{for Region V} \end{cases} \quad \text{Rounded to the nearest standardized DHR given in Table 18.}$$

where $\dot{Q}_h^k(47)$ is expressed in units of Btu/h and otherwise defined as follows:

1. For a single-speed heat pump tested as per section 3.6.1, $\dot{Q}_h^k(47) = \dot{Q}_h(47)$, the space heating capacity determined from the H1 Test.

2. For a variable-speed heat pump, a section 3.6.2 single-speed heat pump, or a two-capacity heat pump not covered by item 3, $\dot{Q}_h^k(47) = \dot{Q}_h^{k=2}(47)$, the space heating capacity determined from the $H1_2$ Test.

3. For two-capacity, northern heat pumps (see Definition 1.46), $\dot{Q}^k_h(47) = \dot{Q}^{k=1}_h(47)$, the space heating capacity determined from the $H1_1$ Test.

If the optional $H1_N$ Test is conducted on a variable-speed heat pump, the manufacturer has the option of defining $\dot{Q}^k_h(47)$ as specified above in item 2 or as $\dot{Q}^k_h(47)=\dot{Q}^{k=N}_h(47)$, the space heating capacity determined from the $H1_N$ Test.

For all heat pumps, HSPF accounts for the heating delivered and the energy consumed by auxiliary resistive elements when operating below the balance point. This condition occurs when the building load exceeds the space heating capacity of the heat pump condenser. For HSPF calculations for all heat pumps, see either section 4.2.1, 4.2.2, 4.2.3, or 4.2.4, whichever applies.

For heat pumps with heat comfort controllers (see Definition 1.28), HSPF also accounts for resistive heating contributed when operating above the heat-pump-plus-comfort-controller balance point as a result of maintaining a minimum supply temperature. For heat pumps having a heat comfort controller, see section 4.2.5 for the additional steps required for calculating the HSPF.

TABLE 18—STANDARDIZED DESIGN HEATING REQUIREMENTS (BTU/H)

5,000	25,000	50,000	90,000
10,000	30,000	60,000	100,000
15,000	35,000	70,000	110,000
20,000	40,000	80,000	130,000

4.2.1 Additional steps for calculating the HSPF of a heat pump having a single-speed compressor that was tested with a fixed-speed indoor fan installed, a constant-air-volume-rate indoor fan installed, or with no indoor fan installed.

$$\frac{e_h(T_j)}{N} = \frac{X(T_j) \cdot \dot{E}_h(T_j) \cdot \delta(T_j)}{PLF_j} \cdot \frac{n_j}{N} \qquad (4.2.1\text{-}1)$$

$$\frac{RH(T_j)}{N} = \frac{BL(T_j) - \left[X(T_j) \cdot \dot{Q}_h(T_j) \cdot \delta(T_j)\right]}{3.413 \dfrac{Btu/h}{W}} \cdot \frac{n_j}{N} \qquad (4.2.1\text{-}2)$$

where,

$$X(T_j) = \begin{cases} BL(T_J) / \dot{Q}_h(T_j) \\ \text{or} \\ 1 \end{cases}$$

whichever is less; the heating mode load factor for temperature bin j, dimensionless.

$\dot{Q}_h(T_j)$ = the space heating capacity of the heat pump when operating at outdoor temperature T_j, Btu/h.

$\dot{E}_h(T_j)$ = the electrical power consumption of the heat pump when operating at outdoor temperature T_j, W.

$\delta(T_j)$ = the heat pump low temperature cut-out factor, dimensionless.

$PLF_j = 1 - C_D^h \cdot [1 - X(T_j)]$ the part load factor, dimensionless.

Use Equation 4.2–2 to determine $BL(T_j)$. Obtain fractional bin hours for the heating season, n_j/N, from Table 17. If the optional H1C Test described in section 3.6.1 is not conducted, set the heating mode cyclic degradation coefficient, C_D^h, to the default value specified in section 3.8.1. If this optional test is conducted, set C_D^h to the lower of:

a. The value calculated according to section 3.8.1 or

b. The section 3.8.1 default value of 0.25.

Determine the low temperature cut-out factor using

$$\delta(T_j) = \begin{cases} 0, \text{ if } T_j \le T_{off} \text{ or } \dfrac{\dot{Q}_h(T_j)}{3.413 \cdot \dot{E}_h(T_j)} < 1 \\ 1/2, \text{ if } T_{off} < T_j \le T_{on} \text{ and } \dfrac{\dot{Q}_h(T_j)}{3.413 \cdot \dot{E}_h(T_j)} \ge 1 \\ 1, \text{ if } T_j > T_{on} \text{ and } \dfrac{\dot{Q}_h(T_j)}{3.413 \cdot \dot{E}_h(T_j)} \ge 1 \end{cases} \qquad (4.2.1\text{-}3)$$

where,

T_{off} = the outdoor temperature when the compressor is automatically shut off, °F. (If no such temperature exists, T_j is always greater than T_{off} and T_{on}).

T_{on} = the outdoor temperature when the compressor is automatically turned back on, if applicable, following an automatic shut-off, °F.

Calculate $\dot{Q}_h(T_j)$ and $\dot{E}_h(T_j)$ using,

$$\dot{Q}_h(T_j) = \begin{cases} \dot{Q}_h(17) + \dfrac{[\dot{Q}_h(47) - \dot{Q}_h(17)] \cdot (T_j - 17)}{47 - 17}, \text{ if } T_j \ge 45\ ^\circ\text{F or } T_j \le 17\ ^\circ\text{F} \\ \dot{Q}_h(17) + \dfrac{[\dot{Q}_h(35) - \dot{Q}_h(17)] \cdot (T_j - 17)}{35 - 17}, \text{ if } 17\ ^\circ\text{F} < T_j < 45\ ^\circ\text{F} \end{cases} \qquad (4.2.1\text{-}4)$$

$$\dot{E}_h(T_j) = \begin{cases} \dot{E}_h(17) + \dfrac{[\dot{E}_h(47) - \dot{E}_h(17)] \cdot (T_j - 17)}{47 - 17}, \text{ if } T_j \ge 45\ ^\circ\text{F or } T_j \le 17\ ^\circ\text{F} \\ \dot{E}_h(17) + \dfrac{[\dot{E}_h(35) - \dot{E}_h(17)] \cdot (T_j - 17)}{35 - 17}, \text{ if } 17\ ^\circ\text{F} < T_j < 45\ ^\circ\text{F} \end{cases} \qquad (4.2.1\text{-}5)$$

where $\dot{Q}_h(47)$ and $\dot{E}_h(47)$ are determined from the H1 Test and calculated as specified in section 3.7; $\dot{Q}_h(35)$ and $\dot{E}_h(35)$ are determined from the H2 Test and calculated as specified in section 3.9.1; and $\dot{Q}_h(17)$ and $\dot{E}_h(17)$ are determined from the H3 Test and calculated as specified in section 3.10.

4.2.2 Additional steps for calculating the HSPF of a heat pump having a single-speed compressor and a variable-speed, variable-air-volume-rate indoor fan. The manufacturer must provide information about how the indoor air volume rate or the indoor fan speed varies over the outdoor temperature range of 65 °F to −23 °F. Calculate the quantities

$$\frac{e_h(T_j)}{N} \text{ and } \frac{RH(T_j)}{N}$$

in Equation 4.2–1 as specified in section 4.2.1 with the exception of replacing references to the H1C Test and section 3.6.1 with the $H1C_1$ Test and section 3.6.2. In addition, evaluate the space heating capacity and electrical power consumption of the heat pump $\dot{Q}_h(T_j)$ and $\dot{E}_h(T_j)$ using

$$\dot{Q}_h(T_j) = \dot{Q}_h^{k=1}(T_j) + \frac{\dot{Q}_h^{k=2}(T_j) - \dot{Q}_h^{k=1}(T_j)}{FP_h^{k=2} - FP_h^{k=1}} \cdot \left[FP_h(T_j) - FP_h^{k=1}\right] \qquad (4.2.2\text{-}1)$$

$$\dot{E}_h(T_j) = \dot{E}_h^{k=1}(T_j) + \frac{\dot{E}_h^{k=2}(T_j) - \dot{E}_h^{k=1}(T_j)}{FP_h^{k=2} - FP_h^{k=1}} \cdot \left[FP_h(T_j) - FP_h^{k=1}\right] \qquad (4.2.2\text{-}2)$$

where the space heating capacity and electrical power consumption at both low capacity (k=1) and high capacity (k=2) at outdoor temperature Tj are determined using

$$\dot{Q}_h^k(T_j) = \begin{cases} \dot{Q}_h^k(17) + \dfrac{\left[\dot{Q}_h^k(47) - \dot{Q}_h^k(17)\right] \cdot (T_j - 17)}{47 - 17}, & \text{if } T_j \geq 45\ ^\circ\text{F or } T_j \leq 17\ ^\circ\text{F} \\[2ex] \dot{Q}_h^k(17) + \dfrac{\left[\dot{Q}_h^k(35) - \dot{Q}_h^k(17)\right] \cdot (T_j - 17)}{35 - 17}, & \text{if } 17\ ^\circ\text{F} < T_j < 45\ ^\circ\text{F} \end{cases} \qquad (4.2.2\text{-}3)$$

$$\dot{E}_h^k(T_j) = \begin{cases} E_h^k(17) + \dfrac{\left[\dot{E}_h^k(47) - \dot{E}_h^k(17)\right] \cdot (T_j - 17)}{47 - 17}, & \text{if } T_j \geq 45\ ^\circ\text{F or } T_j \leq 17\ ^\circ\text{F} \\[2ex] \dot{E}_h^k(17) + \dfrac{\left[\dot{E}_h^k(35) - \dot{E}_h^k(17)\right] \cdot (T_j - 17)}{35 - 17}, & \text{if } 17\ ^\circ\text{F} < T_j < 45\ ^\circ\text{F} \end{cases} \qquad (4.2.2\text{-}4)$$

For units where indoor fan speed is the primary control variable, $FP_h^{k=1}$ denotes the fan speed used during the required $H1_1$ and $H3_1$ Tests (see Table 10), $FP_h^{k=2}$ denotes the fan speed used during the required $H1_2$, $H2_2$, and $H3_2$ Tests, and $FP_h(T_j)$ denotes the fan speed used by the unit when the outdoor temperature equals T_j. For units where indoor air volume rate is the primary control variable, the three FP_h's are similarly defined only now being expressed in terms of air volume rates rather than fan speeds. Determine $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ from the $H1_1$ Test, and $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ from the $H1_2$ Test. Calculate all four quantities as specified in section 3.7. Determine $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ as specified in section 3.6.2; determine $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ and from the $H2_2$ Test and the calculation specified in section 3.9. Determine $\dot{Q}_h^{k=1}(17)$ and $\dot{E}_h^{k=1}$(17 from the $H3_1$ Test, and $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ Test. Calculate all four quantities as specified in section 3.10.

4.2.3 Additional steps for calculating the HSPF of a heat pump having a two-capacity compressor. The calculation of the Equation 4.2–1 quantities

$$\frac{e_h(T_j)}{N} \text{ and } \frac{RH(T_j)}{N}$$

differs depending upon whether the heat pump would operate at low capacity (section 4.2.3.1), cycle between low and high capacity (Section 4.2.3.2), or operate at high capacity (sections 4.2.3.3 and 4.2.3.4) in responding to the building load. For heat pumps that lock out low capacity operation at low outdoor temperatures, the manufacturer must supply information regarding the cutoff temperature(s) so that the appropriate equations can be selected.

a. Evaluate the space heating capacity and electrical power consumption of the heat pump when operating at low compressor capacity and outdoor temperature T_j using

$$\dot{Q}_h^{k=1}(T_j) = \begin{cases} \dot{Q}_h^{k=1}(47) + \dfrac{\left[\dot{Q}_h^{k=1}(62) - \dot{Q}_h^{k=1}(47)\right]\cdot\left(T_j - 47\right)}{62 - 47}, \text{if } T_j \geq 40\ °F \\ \dot{Q}_h^{k=1}(17) + \dfrac{\left[\dot{Q}_h^{k=1}(35) - \dot{Q}_h^{k=1}(17)\right]\cdot\left(T_j - 17\right)}{35 - 17}, \text{if } 17\ °F \leq T_j < 40\ °F \\ \dot{Q}_h^{k=1}(17) + \dfrac{\left[\dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=1}(17)\right]\cdot\left(T_j - 17\right)}{47 - 17}, \text{if } T_j < 17\ °F \end{cases}$$

$$\dot{E}_h^{k=1}(T_j) = \begin{cases} \dot{E}_h^{k=1}(47) + \dfrac{\left[\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)\right]\cdot\left(T_j - 47\right)}{62 - 47}, \text{ if } T_j \geq 40\ °F \\ \dot{E}_h^{k=1}(17) + \dfrac{\left[\dot{E}_h^{k=1}(35) - \dot{E}_h^{k=1}(17)\right]\cdot\left(T_j - 17\right)}{35 - 17}, \text{ if } 17\ °F \leq T_j < 40\ °F \\ \dot{E}_h^{k=1}(17) + \dfrac{\left[\dot{E}_h^{k=1}(47) - \dot{E}_h^{k=1}(17)\right]\cdot\left(T_j - 17\right)}{47 - 17}, \text{ if } T_j < 17\ °F \end{cases}$$

b. Evaluate the space heating capacity and electrical power consumption ($\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$) of the heat pump when operating at high compressor capacity and outdoor temperature Tj by solving Equations 4.2.2–3 and 4.2.2–4, respectively, for k=2. Determine $\dot{Q}_h^{k=1}(62)$ and $\dot{E}_h^{k=1}(62)$ from the $H0_1$ Test, $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ from the $H1_1$ Test, and $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ from the $H1_2$ Test. Calculate all six quantities as specified in section 3.7. Determine $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ from the $H2_2$ Test and, if required as described in section 3.6.3, determine $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ from the $H2_1$ Test. Calculate the required 35 °F quantities as specified in section 3.9. Determine $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ Test and, if required as described in section 3.6.3, determine $\dot{Q}_h^{k=1}(17)$ and $\dot{E}_h^{k=1}(17)$ from the $H3_1$ Test. Calculate the required 17 °F quantities as specified in section 3.10.

4.2.3.1 Steady-state space heating capacity when operating at low compressor capacity is greater than or equal to the building heating load at temperature T_j, $\dot{Q}_h^{k=1}(T_j) \geq BL(T_j)$.

$$\frac{e_h(T_j)}{N} = \frac{X^{k=1}(T_j)\cdot\dot{E}_h^{k=1}(T_j)\cdot\delta'(T_j)}{PLF_j}\cdot\frac{n_j}{N} \qquad (4.2.3\text{-}1)$$

$$\frac{RH(T_j)}{N} = \frac{BL(T_j)\cdot\left[1-\delta'(T_j)\right]}{3.413\dfrac{Btu/h}{W}}\cdot\frac{n_j}{N} \qquad (4.2.3\text{-}2)$$

where,

$X^{k=1}(T_j) = BL(T_j) / \dot{Q}_h^{k=1}(T_j)$, the heating mode low capacity load factor for temperature bin *j*, dimensionless.

$PLF_j = 1 - C_D^h \cdot [1 - X^{k=1}(T_j)]$, the part load factor, dimensionless.

$\delta'(T_j)$ = the low temperature cutoff factor, dimensionless.

If the optional $H0C_1$ Test described in section 3.6.3 is not conducted, set the heating mode cyclic degradation coefficient, C_D^h, to the default value specified in section 3.8.1. If this optional test is conducted, set C_D^h to the lower of:

a. The value calculated according to section 3.8.1; or

b. The section 3.8.1 default value of 0.25.

Determine the low temperature cut-out factor using

$$\delta'(T_j) = \begin{cases} 0, & \text{if } T_j \le T_{off} \\ 1/2, & \text{if } T_{off} < T_j \le T_{on} \\ 1, & \text{if } T_j > T_{on} \end{cases} \qquad (4.2.3\text{-}3)$$

where T_{off} and T_{on} are defined in section 4.2.1. Use the calculations given in section 4.2.3.3, and not the above, if:

(a) The heat pump locks out low capacity operation at low outdoor temperatures and

(b) T_j is below this lockout threshold temperature.

4.2.3.2 Heat pump alternates between high (k=2) and low (k=1) compressor capacity to satisfy the building heating load at a temperature T_j, $\dot{Q}_h^{k=1}(T_j) < BL(T_j) < \dot{Q}_h^{k=2}(T_j)$. Calculate

$$\frac{RH(T_j)}{N}$$

using Equation 4.2.3–2. Evaluate

$$\frac{e_h(T_j)}{N}$$

using

$$\frac{e_h(T_j)}{N} = \left[X^{k=1}(T_j) \cdot \dot{E}_h^{k=1}(T_j) + X^{k=2}(T_j) \cdot \dot{E}_h^{k=2}(T_j)\right] \cdot \delta'(T_j) \cdot \frac{n_j}{N}$$

where,

$$X^{k=1}(T_j) = \frac{\dot{Q}_h^{k=2}(T_j) - BL(T_j)}{\dot{Q}_h^{k=2}(T_j) - \dot{Q}_h^{k=1}(T_j)}$$

$X^{k=2}(T_j) = 1 - X^{k=1}(T_j)$ the heating mode, high capacity load factor for temperature bin $_j$, dimensionless.

Determine the low temperature cut-out factor, $\delta'(T_j)$, using Equation 4.2.3–3.

4.2.3.3 Heat pump only operates at high (k=2) compressor capacity at temperature T_j and its capacity is greater than the building heating load, $BL(T_j) < \dot{Q}_h^{k=2}(T_j)$. This section applies to units that lock out low compressor capacity operation at low outdoor temperatures. Calculate

$$\frac{RH(T_j)}{N}$$

using Equation 4.2.3–2. Evaluate

$$\frac{e_h(T_j)}{N}$$

using

$$\frac{e_h(T_j)}{N} = \frac{X^{k=2}(T_j) \cdot \dot{E}_h^{k=2}(T_j) \cdot \delta'(T_j)}{PLF_j} \cdot \frac{n_j}{N}$$

where,

$X^{k=2}(T_j) = BL(T_j)/\dot{Q}_h^{k=2}(T_j)$.

$$PLF_j = 1 - C_D^h(k=2) \cdot \left[1 - X^{k=2}(T_j)\right].$$

If the optional H1C$_2$ Test described in section 3.6.3 and Table 11 is not conducted, set C_D^h (k=2) equal to the default value specified in section 3.8.1. If this optional test is conducted, set C_D^h (k=2) to the lower of:

a. the C_D^h (k=2) value calculated as per section 3.8.1; or

b. the section 3.8.1 default value for C_D^h (k=2).

Determine the low temperature cut-out factor, $\delta(T_j)$, using Equation 4.2.3–3.

4.2.3.4 Heat pump must operate continuously at high (k=2) compressor capacity at temperature T_j, $BL(T_j) \geq \dot{Q}_h^{k=2}(T_j)$.

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=2}(T_j) \cdot \delta''(T_j) \cdot \frac{n_j}{N}$$

$$\frac{RH(T_j)}{N} = \frac{BL(T_j) - \left[\dot{Q}_h^{k=2}(T_j) \cdot \delta''(T_j)\right]}{3.413 \ \frac{Btu/h}{W}} \cdot \frac{n_j}{N}$$

Where

$$\delta''(T_j) = \begin{cases} 0, & \text{if } T_j \leq T_{off} \text{ or } \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 \cdot \dot{E}_h^{k=2}(T_j)} < 1 \\ 1/2, & \text{if } T_{off} < T_j \leq T_{on} \text{ and } \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 \cdot \dot{E}_h^{k=2}(T_j)} \geq 1 \\ 1, & \text{if } T_j > T_{on} \text{ and } \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 \cdot \dot{E}_h^{k=2}(T_j)} \geq 1 \end{cases}$$

4.2.4 Additional steps for calculating the HSPF of a heat pump having a variable-speed compressor. Calculate HSPF using Equation 4.2–1. Evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$, of the heat pump when operating at minimum compressor speed and outdoor temperature T_j using

$$\dot{Q}_h^{k=1}(T_j) = \dot{Q}_h^{k=1}(47) + \frac{\dot{Q}_h^{k=1}(62) - \dot{Q}_h^{k=1}(47)}{62 - 47} \cdot (T_j - 47) \qquad (4.2.4\text{-}1)$$

$$\dot{E}_h^{k=1}(T_j) = \dot{E}_h^{k=1}(47) + \frac{\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)}{62 - 47} \cdot (T_j - 47) \qquad (4.2.4\text{-}2)$$

where $\dot{Q}_h^{k=1}(62)$ and $\dot{E}_h^{k=1}(62)$ are determined from the H0$_1$ Test, $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ are determined from the H1$_1$ Test, and all four quantities are calculated as specified in section 3.7. Evaluate the space heating capacity, $\dot{Q}_h^{k=2}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=2}(T_j)$, of the heat pump when operating at maximum compressor speed and outdoor temperature T_j by solving Equations 4.2.2–3 and 4.2.2–4, respectively, for k=2. Determine the Equation 4.2.2–3 and 4.2.2–4 quantities $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ from the H1$_2$ Test and the calculations specified in section 3.7. Determine $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ from the H2$_2$ Test and the calculations specified in section 3.9 or, if the H2$_2$ Test is not conducted, by conducting the calculations specified in section 3.6.4. Determine $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the H3$_2$ Test and the calculations specified in section 3.10. Calculate the space heating capacity, $\dot{Q}_h^{k=v}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=v}(T_j)$, of the heat pump when operating at outdoor temperature T_j and the intermediate compressor speed used during the section 3.6.4 H2$_V$ Test using

$$\dot{Q}_h^{k=v}\left(T_j\right) = \dot{Q}_h^{k=v}(35) + M_Q \cdot \left(T_j - 35\right) \qquad (4.2.4\text{-}3)$$

$$\dot{E}_h^{k=v}\left(T_j\right) = \dot{E}_h^{k=v}(35) + M_E \cdot \left(T_j - 35\right) \qquad (4.2.4\text{-}4)$$

where $\dot{Q}_h^{k=v}(35)$ and $\dot{E}_h^{k=v}(35)$ are determined from the H2$_V$ Test and calculated as specified in section 3.9. Approximate the slopes of the k=v intermediate speed heating capacity and electrical power input curves, M_Q and M_E, as follows:

$$M_Q = \left[\frac{\dot{Q}_h^{k=1}(62) - \dot{Q}_h^{k=1}(47)}{62-47} \cdot \left(1 - N_Q\right)\right] + \left[N_Q \cdot \frac{\dot{Q}_h^{k=2}(35) - \dot{Q}_h^{k=2}(17)}{35-17}\right]$$

$$M_E = \left[\frac{\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)}{62-47} \cdot \left(1 - N_E\right)\right] + \left[N_E \cdot \frac{\dot{E}_h^{k=2}(35) - \dot{E}_h^{k=2}(17)}{35-17}\right]$$

where,

$$N_Q = \frac{\dot{Q}_h^{k=v}(35) - \dot{Q}_h^{k=1}(35)}{\dot{Q}_h^{k=2}(35) - \dot{Q}_h^{k=1}(35)}, \text{ and}$$

$$N_E = \frac{\dot{E}_h^{k=v}(35) - \dot{E}_h^{k=1}(35)}{\dot{E}_h^{k=2}(35) - \dot{E}_h^{k=1}(35)}.$$

Use Equations 4.2.4–1 and 4.2.4–2, respectively, to calculate $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$.

The calculation of Equation 4.2–1 quantities

$$\frac{e_h\left(T_j\right)}{N} \text{ and } \frac{RH\left(T_j\right)}{N}$$

differs depending upon whether the heat pump would operate at minimum speed (section 4.2.4.1), operate at an intermediate speed (section 4.2.4.2), or operate at maximum speed (section 4.2.4.3) in responding to the building load.

4.2.4.1 Steady-state space heating capacity when operating at minimum compressor speed is greater than or equal to the building heating load at temperature T_j, $\dot{Q}_h^{k=1}(T_j \geq BL(T_j)$. Evaluate the Equation 4.2–1 quantities

$$\frac{e_h\left(T_j\right)}{N} \text{ and } \frac{RH\left(T_j\right)}{N}$$

as specified in section 4.2.3.1. Except now use Equations 4.2.4–1 and 4.2.4–2 to evaluate $\dot{Q}_h^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j)$, respectively, and replace section 4.2.3.1 references to ‘‘low capacity’’ and section 3.6.3 with ‘‘minimum speed’’ and section 3.6.4. Also, the last sentence of section 4.2.3.1 does not apply.

4.2.4.2 Heat pump operates at an intermediate compressor speed (k=i) in order to match the building heating load at a temperature T_j, $\dot{Q}_h^{k=1}(T_j) < BL(T_j) < \dot{Q}_h^{k=2}(T_j)$. Calculate

$$\frac{RH\left(T_j\right)}{N}$$

using Equation 4.2.3–2 while evaluating

$$\frac{e_h\left(T_j\right)}{N}$$

using,

$$\frac{e_h\left(T_j\right)}{N} = \dot{E}_h^{k=1}\left(T_j\right) \cdot \delta'\left(T_j\right) \cdot \frac{n_j}{N}$$

where,

$$\dot{E}_h^{k=i}\left(T_j\right) = \frac{\dot{Q}_h^{k=i}\left(T_j\right)}{3.413 \dfrac{Btu/h}{W} \cdot COP^{k=i}\left(T_j\right)}$$

and $\delta(T_j)$ is evaluated using Equation 4.2.3–3 while,

$\dot{Q}_h^{k=i}(T_j) = BL(T_j)$, the space heating capacity delivered by the unit in matching the building load at temperature (T_j), Btu/h. The matching occurs with the heat pump operating at compressor speed k=i.

$COP^{k=i}(T_j)$ = the steady-state coefficient of performance of the heat pump when operating at compressor speed k=i and temperature T_j, dimensionless.

For each temperature bin where the heat pump operates at an intermediate compressor speed, determine $COP^{k=i}(T_j)$ using,

$COP^{k=i}(T_j) = A + B \cdot T_j + C \cdot T_j^2$.

For each heat pump, determine the coefficients A, B, and C by conducting the following calculations once:

$$D = \frac{T_3^2 - T_4^2}{T_{vh}^2 - T_4^2}$$

$$B = \frac{COP^{k=2}(T_4) - COP^{k=1}(T_3) - D \cdot \left[COP^{k=2}(T_4) - COP^{k=v}(T_{vh})\right]}{T_4 - T_3 - D \cdot (T_4 - T_{vh})}$$

$$C = \frac{COP^{k=2}(T_4) - COP^{k=1}(T_3) - B \cdot (T_4 - T_3)}{T_4^2 - T_3^2}$$

$$A = COP^{k=2}(T_4) - B \cdot T_4 - C \cdot T_4^2.$$

where,

T_3 = the outdoor temperature at which the heat pump, when operating at minimum compressor speed, provides a space heating capacity that is equal to the building load ($\dot{Q}_h^{k=1}(T_3) = BL(T_3)$), °F. Determine T_3 by equating Equations 4.2.4–1 and 4.2–2 and solving for outdoor temperature.

T_{vh} = the outdoor temperature at which the heat pump, when operating at the intermediate compressor speed used during the section 3.6.4 $H2_V$ Test, provides a space heating capacity that is equal to the building load ($\dot{Q}_h^{k=v}(T_{vh}) = BL(T_{vh})$), °F. Determine T_{vh} by equating Equations 4.2.4–3 and 4.2–2 and solving for outdoor temperature.

T_4 = the outdoor temperature at which the heat pump, when operating at maximum compressor speed, provides a space heating capacity that is equal to the building load ($\dot{Q}_h^{k=2}(T_4) = BL(T_4)$), °F. Determine T_4 by equating Equations 4.2.2–3 (k=2) and 4.2–2 and solving for outdoor temperature.

$$COP^{k=1}(T_3) = \frac{\dot{Q}_h^{k=1}(T_3)\left[\text{Eqn. 4.2.4 - 1, substituting } T_3 \text{ for } T_j\right]}{3.413\frac{\text{Btu/h}}{\text{W}} \cdot \dot{E}_h^{k=1}(T_3)\left[\text{Eqn. 4.2.4 - 2, substituting } T_3 \text{ for } T_j\right]}$$

$$COP^{k=v}(T_{vh}) = \frac{\dot{Q}_h^{k=v}(T_{vh})\ \left[\text{Eqn. 4.2.4-3, substituting } T_{vh} \text{ for } T_j\right]}{3.413\,\frac{Btu/h}{W} \cdot \dot{E}_h^{k=v}(T_{vh})\ \left[\text{Eqn. 4.2.4-4, substituting } T_{vh} \text{ for } T_j\right]}$$

$$COP^{k=2}(T_4) = \frac{\dot{Q}_h^{k=2}(T_4)\ \left[\text{Eqn. 4.2.2-3, substituting } T_4 \text{ for } T_j\right]}{3.413\,\frac{Btu/h}{W} \cdot \dot{E}_h^{k=2}(T_4)\ \left[\text{Eqn. 4.2.2-4, substituting } T_4 \text{ for } T_j\right]}$$

For multiple-split heat pumps (only), the following procedures supersede the above requirements for calculating $COP_h^{k=i}(T_j)$. For each temperature bin where $T_3 > T_j > T_{vh}$,

$$COP_h^{k=i}(T_j) = COP_h^{k=1}(T_3) + \frac{COP_h^{k=v}(T_{vh}) - COP_h^{k=1}(T_3)}{T_{vh} - T_3} \cdot (T_j - T_3).$$

For each temperature bin where $T_{vh} \ge T_j > T_4$,

$$COP_h^{k=i}(T_j) = COP_h^{k=v}(T_{vh}) + \frac{COP_h^{k=2}(T_4) - COP_h^{k=v}(T_{vh})}{T_4 - T_{vh}} \cdot (T_j - T_{vh}).”$$

4.2.4.3 Heat pump must operate continuously at maximum (k=2) compressor speed at temperature T_j, $BL(T_j) \ge \dot{Q}_h^{k=2}(T_j)$. Evaluate the Equation 4.2–1 quantities

$$\frac{e_h(T_j)}{N} \text{ and } \frac{RH(T_j)}{N}$$

as specified in section 4.2.3.4 with the understanding that $\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$ correspond to maximum compressor speed operation and are derived from the results of the specified section 3.6.4 tests.

4.2.5 Heat pumps having a heat comfort controller. Heat pumps having heat comfort controllers, when set to maintain a typical minimum air delivery temperature, will cause the heat pump condenser to operate less because of a greater contribution from the resistive elements. With a conventional heat pump, resistive heating is only initiated if the heat pump condenser cannot meet the building load (*i.e.*, is delayed until a second stage call from the indoor thermostat). With a heat comfort controller, resistive heating can occur even though the heat pump condenser has adequate capacity to meet the building load (*i.e.*, both on during a first stage call from the indoor thermostat). As a result, the outdoor temperature where the heat pump compressor no longer cycles (*i.e.*, starts to run continuously), will be lower than if the heat pump did not have the heat comfort controller.

4.2.5.1 Heat pump having a heat comfort controller: additional steps for calculating the HSPF of a heat pump having a single-speed compressor that was tested with a fixed-speed indoor fan installed, a constant-air-volume-rate indoor fan installed, or with no indoor fan installed. Calculate the space heating capacity and electrical power of the heat pump without the heat comfort controller being active as specified in section 4.2.1 (Equations 4.2.1–4 and 4.2.1–5) for each outdoor bin temperature, T_j, that is listed in Table 17. Denote these capacities and electrical powers by using the subscript ‘‘hp’’ instead of ‘‘h.’’ Calculate the mass flow rate (expressed in pounds-mass of dry air per hour) and the specific heat of the indoor air (expressed in $Btu/lbm_{da} \cdot °F$) from the results of the H1 Test using:

$$\dot{m}_{da} = \overline{\dot{V}}_s \cdot 0.075\ \frac{1bm_{da}}{ft^3} \cdot \frac{60\ min}{hr} = \frac{\overline{\dot{V}}_{mx}}{v'_n \cdot \left[1 + W_n\right]} \cdot \frac{60\ min}{hr} = \frac{\overline{\dot{V}}_{mx}}{v_n} \cdot \frac{60\ min}{hr}$$

$$C_{p,da} = 0.24 + 0.444 \cdot W_n$$

where $\overline{\dot{V}}_s$, $\overline{\dot{V}}_{mx}$, v'_n (or v_n), and W_n are defined following Equation 3–1. For each outdoor bin temperature listed in Table 17, calculate the nominal temperature of the air leaving the heat pump condenser coil using,

$$T_o\left(T_j\right) = 70\ °F + \frac{\dot{Q}_{hp}\left(T_j\right)}{\dot{m}_{da} \cdot C_{p,da}}.$$

Evaluate $e_h(T_j/N)$, $RH(T_j)/N$, $X(T_j)$, PLF_j, and $\delta(T_j)$ as specified in section 4.2.1. For each bin calculation, use the space heating capacity and electrical power from Case 1 or Case 2, whichever applies.

Case 1. For outdoor bin temperatures where $T_o(T_j)$ is equal to or greater than T_{CC} (the maximum supply temperature determined according to section 3.1.9), determine $\dot{Q}_h(T_j)$ and $\dot{E}_h(T_j)$ as specified in section 4.2.1 (*i.e.*, $\dot{Q}_h(T_j) = \dot{Q}_{hp}(T_j)$ and $\dot{E}_{hp}(T_j) = \dot{E}_{hp}(T_j)$). Note: Even though $T_o(T_j) \geq T_{cc}$, resistive heating may be required; evaluate Equation 4.2.1–2 for all bins.

Case 2. For outdoor bin temperatures where $T_o(T_j) > T_{cc}$, determine $\dot{Q}_h(T_j)$ and $\dot{E}_h(T_j)$ using,

$$\dot{Q}_h\left(T_j\right) = \dot{Q}_{hp}\left(T_j\right) + \dot{Q}_{CC}\left(T_j\right)$$

$$\dot{E}_h\left(T_j\right) = \dot{E}_{hp}\left(T_j\right) + \dot{E}_{CC}\left(T_j\right)$$

where,

$$\dot{Q}_{CC}\left(T_j\right) = \dot{m}_{da} \cdot C_{p,da} \cdot \left[T_{CC} - T_o\left(T_j\right)\right]$$

$$\dot{E}_{CC}\left(T_j\right) = \frac{\dot{Q}_{CC}\left(T_j\right)}{3.413\ \frac{Btu}{W \cdot h}}$$

NOTE: Even though $T_o(T_j) < T_{cc}$, additional resistive heating may be required; evaluate Equation 4.2.1–2 for all bins.

4.2.5.2 Heat pump having a heat comfort controller: additional steps for calculating the HSPF of a heat pump having a single-speed compressor and a variable-speed, variable-air-volume-rate indoor fan. Calculate the space heating capacity and electrical power of the heat pump without the heat comfort controller being active as specified in section 4.2.2 (Equations 4.2.2–1 and 4.2.2–2) for each outdoor bin temperature, T_j, that is listed in Table 17. Denote these capacities and electrical powers by using the subscript ''hp'' instead of ''h.'' Calculate the mass flow rate (expressed in pounds-mass of dry air per hour) and the specific heat of the indoor air (expressed in $Btu/lbm_{da} \cdot °F$) from the results of the $H1_2$ Test using:

$$\dot{m}_{da} = \overline{\dot{V}}_s \cdot 0.075\ \frac{1bm_{da}}{ft^3} \cdot \frac{60\ min}{hr} = \frac{\overline{\dot{V}}_{mx}}{v'_n \cdot \left[1 + W_n\right]} \cdot \frac{60\ min}{hr} = \frac{\overline{\dot{V}}_{mx}}{v_n} \cdot \frac{60\ min}{hr}$$

$$C_{p,da} = 0.24 + 0.444 \cdot W_n$$

where $\overline{\dot{V}}_S$, $\overline{\dot{V}}_{mx}$, v'_n (or v_n), and W_n are defined following Equation 3–1. For each outdoor bin temperature listed in Table 17, calculate the nominal temperature of the air leaving the heat pump condenser coil using,

$$T_o\left(T_j\right) = 70\ °F + \frac{\dot{Q}_{hp}\left(T_j\right)}{\dot{m}_{da} \cdot C_{p,da}}.$$

Evaluate $e_h(T_j)/N$, $RH(T_j)/N$, $X(T_j)$, PLF_j, and $\delta(T_j)$ as specified in section 4.2.1 with the exception of replacing references to the H1C Test and section 3.6.1 with the $H1C_1$ Test and section 3.6.2. For each bin calculation, use the space heating capacity and electrical power from Case 1 or Case 2, whichever applies.

Case 1. For outdoor bin temperatures where $T_o(T_j)$ is equal to or greater than T_{CC} (the maximum supply temperature determined according to section 3.1.9), determine $\dot{Q}_h(T_j)$ and $\dot{E}_h(T_j)$ as specified in section 4.2.2 (*i.e.* $\dot{Q}_h(T_j) = \dot{Q}_{hp}(T_j)$ and $\dot{E}_h(T_j) = \dot{E}_{hp}(T_j)$). Note: Even though $T_o(T_j) \geq T_{CC}$, resistive heating may be required; evaluate Equation 4.2.1–2 for all bins.

Case 2. For outdoor bin temperatures where $T_o(T_j) < T_{CC}$, determine $\dot{Q}_h(T_j)$ and $\dot{E}_h(T_j)$ using,

$\dot{Q}_h(T_j) = \dot{Q}_{hp}(T_j) + \dot{Q}_{CC}(T_j)$

$\dot{E}_h(T_j) = \dot{E}_{hp}(T_j) + \dot{E}_{CC}(T_j)$

where,

$\dot{Q}_{CC}(T_j) = \dot{m}_{da} \cdot C_{p,da} \cdot [T_{CC} - T_o(T_j)]$

$$\dot{E}_{CC}\left(T_j\right) = \frac{\dot{Q}_{CC}\left(T_j\right)}{3.413 \frac{\text{Btu}}{\text{W} \cdot \text{h}}}.$$

NOTE: Even though $T_o(T_j) < T_{cc}$, additional resistive heating may be required; evaluate Equation 4.2.1–2 for all bins.

4.2.5.3 Heat pumps having a heat comfort controller: additional steps for calculating the HSPF of a heat pump having a two-capacity compressor. Calculate the space heating capacity and electrical power of the heat pump without the heat comfort controller being active as specified in section 4.2.3 for both high and low capacity and at each outdoor bin temperature, T_j, that is listed in Table 17. Denote these capacities and electrical powers by using the subscript ''hp'' instead of ''h.'' For the low capacity case, calculate the mass flow rate (expressed in pounds-mass of dry air per hour) and the specific heat of the indoor air (expressed in Btu/lbm$_{da}$ · °F) from the results of the $H1_1$ Test using:

$$\dot{m}_{da}^{k=1} = \overline{\dot{V}}_s \cdot 0.075 \frac{\text{lbm}_{da}}{\text{ft}^3} \cdot \frac{60 \text{ min}}{\text{hr}} = \frac{\overline{\dot{V}}_{mx}}{v'_n \cdot \left[1 + W_n\right]} \cdot \frac{60 \text{ min}}{\text{hr}} = \frac{\overline{\dot{V}}_{mx}}{v_n} \cdot \frac{60 \text{ min}}{\text{hr}}$$

$$C_{p,da}^{k=1} = 0.24 + 0.444 \cdot W_n$$

where $\overline{\dot{V}}_s$, $\overline{\dot{V}}_{mx}$, v'_n (or v_n), and W_n are defined following Equation 3–1. For each outdoor bin temperature listed in Table 17, calculate the nominal temperature of the air leaving the heat pump condenser coil when operating at low capacity using,

$$T_o^{k=1}\left(T_j\right) = 70\ °F + \frac{\dot{Q}_{hp}^{k=1}\left(T_j\right)}{\dot{m}_{da}^{k=1} \cdot C_{p,da}^{k=1}}.$$

Repeat the above calculations to determine the mass flow rate ($\dot{m}_{da}^{k=2}$) and the specific heat of the indoor air ($C_{p,da}^{k=2}$) when operating at high capacity by using the results of the $H1_2$ Test. For each outdoor bin temperature listed in Table 17, calculate the nominal temperature of the air leaving the heat pump condenser coil when operating at high capacity using,

$$T_o^{k=2}\left(T_j\right) = 70\ °F + \frac{\dot{Q}_{hp}^{k=2}\left(T_j\right)}{\dot{m}_{da}^{k=2} \cdot C_{p,da}^{k=2}}.$$

Evaluate $e_h(T_j)/N$, $RH(T_j)/N$, $X^{k=1}(T_j)$, and/or $X^{k=2}(T_j)$, PLF_j, and $\delta'(T_j)$ or $\delta''(T_j)$ as specified in section 4.2.3.1. 4.2.3.2, 4.2.3.3, or 4.2.3.4, whichever applies, for each temperature bin. To evaluate these quantities, use the low-capacity space heating capacity and the low-capacity electrical power from Case 1 or Case 2, whichever applies; use the high-capacity space heating capacity and the high-capacity electrical power from Case 3 or Case 4, whichever applies.

Case 1. For outdoor bin temperatures where $T_o^{k=1}(T_j)$ is equal to or greater than T_{CC} (the maximum supply temperature determined according to section 3.1.9), determine $\dot{Q}_h^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j)$ as specified in section 4.2.3 (*i.e.*, $\dot{Q}_h^{k=1}(T_j) = \dot{Q}_{hp}^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j) = \dot{E}_{hp}^{k=1}(T_j)$).

NOTE: Even though $T_o^{k=1}(T_j) \geq T_{CC}$, resistive heating may be required; evaluate $RH(T_j)/N$ for all bins.

Case 2. For outdoor bin temperatures where $T_o^{k=1}(T_j) < T_{CC}$, determine $\dot{Q}_h^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j)$ using,

$\dot{Q}_h^{k=1}(T_j) = \dot{Q}_{hp}^{k=1}(T_j) + \dot{Q}_{CC}^{k=1}(T_j)$

$\dot{E}_h^{k=1}(T_j) = \dot{E}_{hp}^{k=1}(T_j) + \dot{E}_{CC}^{k=1}(T_j)$

where,

$$\dot{Q}_{CC}^{k=1}\left(T_j\right) = \dot{m}_{da}^{k=1} \cdot C_{p,da}^{k=1} \cdot \left[T_{CC} - T_o^{k=1}\left(T_j\right)\right]$$

$$\dot{E}_{CC}^{k=1}\left(T_j\right) = \frac{\dot{Q}_{CC}^{k=1}\left(T_j\right)}{3.413\dfrac{\text{Btu}}{\text{W} \cdot \text{h}}}.$$

NOTE: Even though $T_o^{k=1}(T_j) \geq T_{cc}$, additional resistive heating may be required; evaluate $RH(T_j)/N$ for all bins.

Case 3. For outdoor bin temperatures where $T_o^{k=2}(T_j)$ is equal to or greater than T_{CC}, determine $\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$ as specified in section 4.2.3 (*i.e.*, $\dot{Q}_h^{k=2}(T_j) = \dot{Q}_{hp}^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j) = \dot{E}_{hp}^{k=2}(T_j)$).

NOTE: Even though $T_o^{k=2}(T_j) < T_{CC}$, resistive heating may be required; evaluate $RH(T_j)/N$ for all bins.

Case 4. For outdoor bin temperatures where $T_o^{k=2}(T_j) < T_{CC}$, determine $\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$ using,

$$\dot{Q}_h^{k=2}\left(T_j\right) = \dot{Q}_{hp}^{k=2}\left(T_j\right) + \dot{Q}_{CC}^{k=2}\left(T_j\right)$$

$$\dot{E}_h^{k=2}\left(T_j\right) = \dot{E}_{hp}^{k=2}\left(T_j\right) + \dot{E}_{CC}^{k=2}\left(T_j\right)$$

where,

$$\dot{Q}_{CC}^{k=2}\left(T_j\right) = \dot{m}_{da}^{k=2} \cdot C_{p,da}^{k=2} \cdot \left[T_{CC} - T_o^{k=2}\left(T_j\right)\right]$$

$$\dot{E}_{CC}^{k=2}\left(T_j\right) = \frac{\dot{Q}_{CC}^{k=2}\left(T_j\right)}{3.413\dfrac{\text{Btu}}{\text{W} \cdot \text{h}}}.$$

NOTE: Even though $T_o^{k=2}(T_j) < T_{cc}$, additional resistive heating may be required; evaluate $RH(T_j)/N$ for all bins.

4.2.5.4 Heat pumps having a heat comfort controller: additional steps for calculating the HSPF of a heat pump having a variable-speed compressor. [Reserved]

4.3 Calculations of the Actual and Representative Regional Annual Performance Factors for Heat Pumps.

4.3.1 Calculation of actual regional annual performance factors (APF_A) for a particular location and for each standardized design heating requirement.

$$APF_A = \frac{CLH_A \cdot \dot{Q}_c^k(95) + HLH_A \cdot DHR \cdot C}{\dfrac{CLH_A \cdot \dot{Q}_c^k(95)}{SEER} + \dfrac{HLH_A \cdot DHR \cdot C}{HSPF}}$$

where,

CLH_A = the actual cooling hours for a particular location as determined using the map given in Figure 3, hr.

$\dot{Q}_c^k(95)$ = the space cooling capacity of the unit as determined from the A or A_2 Test, whichever applies, Btu/h.

HLH_A = the actual heating hours for a particular location as determined using the map given in Figure 2, hr.

DHR = the design heating requirement used in determining the HSPF; refer to section 4.2 and Definition 1.22, Btu/h.

C = defined in section 4.2 following Equation 4.2–2, dimensionless.

SEER = the seasonal energy efficiency ratio calculated as specified in section 4.1, Btu/W·h.

HSPF = the heating seasonal performance factor calculated as specified in section 4.2 for the generalized climatic region that includes the particular location of interest (see Figure 2), Btu/W·h. The HSPF should correspond to the actual design heating requirement (DHR), if known. If it does not, it may correspond to one of the standardized design heating requirements referenced in section 4.2.

4.3.2 Calculation of representative regional annual performance factors (APF_R) for each generalized climatic region and for each standardized design heating requirement.

$$APF_R = \frac{CLH_R \cdot \dot{Q}_c^k(95) + HLH_R \cdot DHR \cdot C}{\frac{CLH_R \cdot \dot{Q}_c^k(95)}{SEER} + \frac{HLH_R \cdot DHR \cdot C}{HSPF}}$$

where,

CLH_R = the representative cooling hours for each generalized climatic region, Table 19, hr.

HLH_R = the representative heating hours for each generalized climatic region, Table 19, hr.

HSPF = the heating seasonal performance factor calculated as specified in section 4.2 for the each generalized climatic region and for each standardized design heating requirement within each region, Btu/W.h.

The SEER, $\dot{Q}_c^k(95)$, DHR, and C are the same quantities as defined in section 4.3.1. Figure 2 shows the generalized climatic regions. Table 18 lists standardized design heating requirements.

TABLE 19—REPRESENTATIVE COOLING AND HEATING LOAD HOURS FOR EACH GENERALIZED CLIMATIC REGION

Region	CLH_R	HLH_R
I	2400	750
II	1800	1250
III	1200	1750
IV	800	2250
V	400	2750
VI	200	2750

4.4. Rounding of SEER, HSPF, and APF for reporting purposes. After calculating SEER according to section 4.1, round it off as specified in subpart B 430.23(m)(3)(i) of Title 10 of the Code of Federal Regulations. Round section 4.2 HSPF values and section 4.3 APF values as per §430.23(m)(3)(ii) and (iii) of Title 10 of the Code of Federal Regulations.

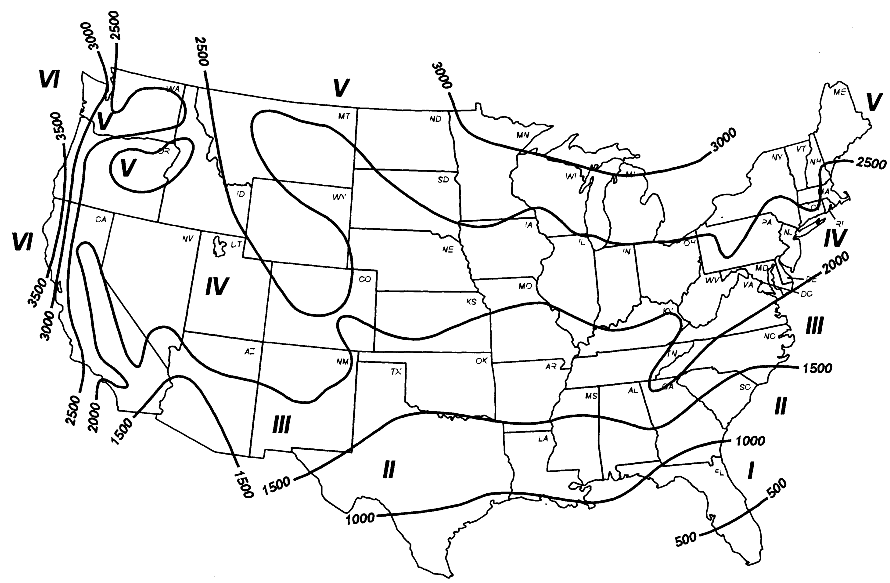


Figure 2 Heating Load Hours (HLH_A) for the United States

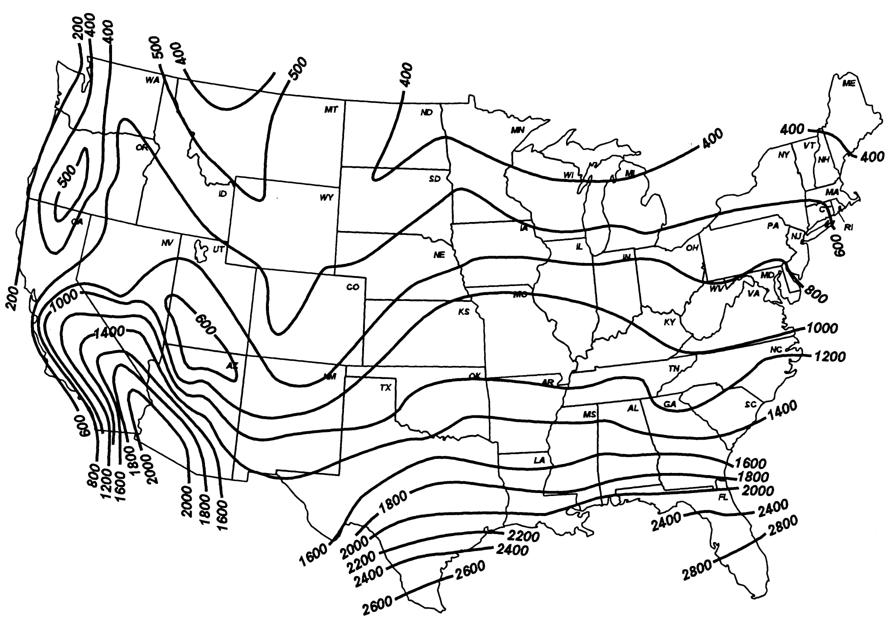


Figure 3 Cooling Load Hours (CLH_A) for the United States

[70 FR 59135, Oct. 11, 2005, as amended at 72 FR 59922, Oct. 22, 2007; 76 FR 37546, June 27, 2011]

EDITORIAL NOTE: At 72 FR 59922, Oct. 22, 2007, appendix M to subpart B of part 430 was amended; however, portions of the amendment could not be incorporated due to inaccurate amendatory instruction.

APPENDIX N TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FURNACES AND BOILERS

NOTE: The procedures and calculations that refer to off mode energy consumption (*i.e.*, sections 8.6 and 10.9 of this appendix N) need not be performed to determine compliance with energy conservation standards for furnaces and boilers at this time. However, any representation related to standby mode and off mode energy consumption of these products made after April 18, 2011 must be based upon results generated under this test procedure, consistent with the requirements of 42 U.S.C. 6293(c)(2). For furnaces manufactured on or after May 1, 2013, compliance with the applicable provisions of this test procedure is required in order to determine compliance with energy conservation standards. For boilers, the statute requires that after July 1, 2010, any adopted energy conservation standard shall address standby mode and off mode energy consumption for these products, and upon the compliance date for such standards, compliance with the applicable provisions of this test procedure will be required.

1.0 Scope. The scope of this appendix is as specified in section 2.0 of ANSI/ASHRAE Standard 103–1993.

2.0 Definitions. Definitions include the definitions specified in section 3 of ANSI/ASHRAE Standard 103–1993 and the following additional and modified definitions:

2.1 *Active mode* means the condition during the heating season in which the furnace or boiler is connected to the power source, and either the burner, electric resistance elements, or any electrical auxiliaries such as blowers or pumps, are activated.

2.2 *ANSI/ASHRAE Standard 103–1993* means the test standard published in 1993 by ASHRAE, approved by the American National Standards Institute (ANSI) on October 4, 1993, and entitled ''Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers'' (with errata of October 24, 1996).

2.3 *ASHRAE* means the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

2.4 *IEC 62301* means the test standard published by the International Electrotechnical Commission (IEC), titled ''Household electrical appliances—Measurement of standby power,'' Publication 62301 (First Edition 2005–06). (incorporated by reference, *see* § 430.3)

2.5 *Isolated combustion system.* The definition of isolation combustion system in section 3 of ANSI/ASHRAE Standard 103–1993 is incorporated with the addition of the following: ''The unit is installed in an un-conditioned indoor space isolated from the heated space.''

2.6 *Off mode* means the condition during the non-heating season in which the furnace or boiler is connected to the power source, and neither the burner, electric resistance elements, nor any electrical auxiliaries such as blowers or pumps, are activated.

2.7 *Seasonal off switch* means the switch on the furnace or boiler that, when activated, results in a measurable change in energy consumption between the standby and off modes.

2.8 *Standby mode* means the condition during the heating season in which the furnace or boiler is connected to the power source, and neither the burner, electric resistance elements, nor any electrical auxiliaries such as blowers or pumps, are activated.

2.9 *Thermal stack damper* means a type of stack damper which is dependent for operation exclusively upon the direct conversion of thermal energy of the stack gases to open the damper.

3.0 Classifications. Classifications are as specified in section 4 of ANSI/ASHRAE Standard 103–1993.

4.0 Requirements. Requirements are as specified in section 5 of ANSI/ASHRAE Standard 103–1993.

5.0 Instruments. Instruments must be as specified in section 6 of ANSI/ASHRAE Standard 103–1993.

6.0 Apparatus. The apparatus used in conjunction with the furnace or boiler during the testing shall be as specified in section 7 of ANSI/ASHRAE Standard 103–1993 except for the second paragraph of section 7.2.2.2 and except for section 7.2.2.5, and as specified in section 6.1 of this appendix.

6.1 *Downflow furnaces.* Install the internal section of vent pipe the same size as the flue collar for connecting the flue collar to the top of the unit, if not supplied by the manufacturer. Do not insulate the internal vent pipe during the jacket loss test (if conducted) described in section 8.6 of ANSI/ASHRAE Standard 103–1993 or the steady-state test described in section 9.1 of ANSI/ASHRAE Standard 103–1993. Do not insulate the internal vent pipe before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ANSI/ASHRAE Standard 103–1993. If the vent pipe is surrounded by a metal jacket, do not insulate the metal jacket. Install a 5-ft test stack of the same cross sectional area or perimeter as the vent pipe above the top of the furnace. Tape or seal around the junction connecting the vent pipe and the 5-ft test stack. Insulate the 5-ft test stack with insulation having an R-value not less than 7 and an outer layer of aluminum foil. (See Figure 3–E of ANSI/ASHRAE Standard 103–1993.)

7.0 Testing conditions. The testing conditions shall be as specified in section 8 of ANSI/ASHRAE Standard 103–1993 with errata of October 24, 1996, except for section 8.6.1.1;

and as specified in section 7.1 of this appendix.

7.1 *Measurement of jacket surface temperature*. The jacket of the furnace or boiler shall be subdivided into 6-inch squares when practical, and otherwise into 36-square-inch regions comprising 4 in. × 9 in. or 3 in. × 12 in. sections, and the surface temperature at the center of each square or section shall be determined with a surface thermocouple. The 36-square-inch areas shall be recorded in groups where the temperature differential of the 36-square-inch area is less than 10 °F for temperature up to 100 °F above room temperature and less than 20 °F for temperature more than 100 °F above room temperature. For forced air central furnaces, the circulating air blower compartment is considered as part of the duct system and no surface temperature measurement of the blower compartment needs to be recorded for the purpose of this test. For downflow furnaces, measure all cabinet surface temperatures of the heat exchanger and combustion section, including the bottom around the outlet duct, and the burner door, using the 36 square-inch thermocouple grid. The cabinet surface temperatures around the blower section do not need to be measured (See figure 3–E of ANSI/ASHRAE Standard 103–1993.)

8.0 Test procedure. Testing and measurements shall be as specified in section 9 of ANSI/ASHRAE Standard 103–1993 except for sections 9.5.1.1, 9.5.1.2.1, 9.5.1.2.2, 9.5.2.1, and section 9.7.1. ; and as specified in sections 8.1, 8.2, 8.3, 8.4, and 8.5, of this appendix.

8.1 *Input to interrupted ignition device*. For burners equipped with an interrupted ignition device, record the nameplate electric power used by the ignition device, PE_{IG}, or use PE_{IG}=0.4 kW if no nameplate power input is provided. Record the nameplate ignition device on-time interval, t_{IG}, or measure the on-time period at the beginning of the test at the time the burner is turned on with a stop watch, if no nameplate value is given. Set t_{IG}=0 and PE_{IG}=0 if the device on-time is less than or equal to 5 seconds after the burner is on.

8.2 *Gas- and oil-fueled gravity and forced air central furnaces without stack dampers cool-down test*. Turn off the main burner after steady-state testing is completed, and measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE 103–1993 at 1.5 minutes ($T_{F,OFF}(t_3)$) and 9 minutes ($T_{F,OFF}(t_4)$) after the burner shuts off. An integral draft diverter shall remain blocked and insulated, and the stack restriction shall remain in place. On atmospheric systems with an integral draft diverter or draft hood, equipped with either an electromechanical inlet damper or an electro-mechanical flue damper that closes within 10 seconds after the burner shuts off to restrict the flow through the heat exchanger in the off-cycle, bypass or adjust the control for the electromechanical damper so that the damper remains open during the cool-down test. For furnaces that employ post purge, measure the length of the post-purge period with a stopwatch. The time from burner OFF to combustion blower OFF (electrically de-energized) shall be recorded as t_p. For the case where t_p is intended to be greater than 180 seconds, stop the combustion blower at 180 seconds and use that value for t_p. Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE 103–1993 at the end of post-purge period, t_p ($T_{F,OFF}(t_p)$), and at the time (1.5 + t_p) minutes ($T_{F,OFF}(t_3)$) and (9.0 + t_p) minutes ($T_{F,OFF}(t_4)$) after the main burner shuts off. For the case where the measured tp is less than or equal to 30 seconds, it shall be tested as if there is no post purge and t_p shall be set equal to 0.

8.3 *Gas- and oil-fueled gravity and forced air central furnaces without stack dampers with adjustable fan control—cool-down test*. For a furnace with adjustable fan control, this time delay will be 3.0 minutes for non-condensing furnaces or 1.5 minutes for condensing furnaces or until the supply air temperature drops to a value of 40 °F above the inlet air temperature, whichever results in the longest fan on-time. For a furnace without adjustable fan control or with the type of adjustable fan control whose range of adjustment does not allow for the delay time specified above, the control shall be bypassed and the fan manually controlled to give the delay times specified above. For a furnace which employs a single motor to drive the power burner and the indoor air circulating blower, the power burner and indoor air circulating blower shall be stopped together.

8.4 *Gas-and oil-fueled boilers without stack dampers cool-down test*. After steady-state testing has been completed, turn the main burner(s) OFF and measure the flue gas temperature at 3.75 ($T_{F,OFF}(t_3)$) and 22.5 ($T_{F,OFF}(t_4)$) minutes after the burner shut off, using the thermocouple grid described in section 7.6 of ANSI/ASHRAE 103–1993. During this off-period, for units that do not have pump delay after shutoff, no water shall be allowed to circulate through the hot water boilers. For units that have pump delay on shutoff, except those having pump controls sensing water temperature, the pump shall be stopped by the unit control and the time t^+, between burner shutoff and pump shutoff shall be measured within one-second accuracy. For units having pump delay controls that sense water temperature, the pump shall be operated for 15 minutes and t^+ shall be 15 minutes. While the pump is operating, the inlet water temperature and flow rate shall be maintained at the same values as used during the steady-state test as specified in sections 9.1 and 8.4.2.3 of ANSI/ASHRAE 103–1993.

For boilers that employ post purge, measure the length of the post-purge period with a stopwatch. The time from burner OFF to combustion blower OFF (electrically de-energized) shall be recorded as t_P. For the case where t_P is intended to be greater than 180 seconds, stop the combustion blower at 180 seconds and use that value for t_P. Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE 103–1993 at the end of the post purge period $t_P(T_{F,OFF}(t_P))$ and at the time $(3.75 + t_P)$ minutes $(T_{F,OFF}(t_3))$ and $(22.5 + t_P)$ minutes $(T_{F,OFF}(t_4))$ after the main burner shuts off. For the case where the measured t_P is less or equal to 30 seconds, it shall be tested as if there is no post purge and t_P shall be set to equal 0.

8.5 *Direct measurement of off-cycle losses testing method.* [Reserved.]

8.6 Measurement of electrical standby and off mode power.

8.6.1 Standby power measurement. With all electrical auxiliaries of the furnace or boiler not activated, measure the standby power $(P_{W,SB})$ in accordance with the procedures in IEC 62301 (incorporated by reference, *see* § 430.3), except that section 8.5 *Room Ambient Temperature* of ASHRAE 103—1993 (incorporated by reference, *see* § 430.3) and the voltage provision of section 8.2.1.4 *Electrical Supply* of ASHRAE 103—1993 shall apply in lieu of the corresponding provisions of IEC 62301 at section 4.2 *Test room* and the voltage specification of section 4.3 *Power supply*. Frequency shall be 60Hz. Clarifying further, IEC 62301 section 4.5 *Power measurement accuracy* and section 5 *Measurements* shall apply in lieu of section 6.10 *Energy Flow Rate* of ASHRAE 103—1993. Measure the wattage so that all possible standby mode wattage for the entire appliance is recorded, not just the standby mode wattage of a single auxiliary.

8.6.2 Off mode power measurement. If the unit is equipped with a seasonal off switch or there is an expected difference between off mode power and standby mode power, measure off mode power $(P_{W,OFF})$ in accordance with the standby power procedures in IEC 62301 (incorporated by reference, *see* § 430.3), except that section 8.5 *Room Ambient Temperature* of ASHRAE 103—1993 (incorporated by reference, *see* § 430.3) and the voltage provision of section 8.2.1.4 *Electrical Supply* of ASHRAE 103—1993 shall apply in lieu of the corresponding provisions of IEC 62301 at section 4.2 *Test room* and the voltage specification of section 4.3 *Power supply*. Frequency shall be 60Hz. Clarifying further, IEC 62301 section 4.5 *Power measurement accuracy* and section 5 *Measurements* shall apply for this measurement in lieu of section 6.10 *Energy Flow Rate* of ASHRAE 103—1993. Measure the wattage so that all possible off mode wattage for the entire appliance is recorded, not just the off mode wattage of a single auxiliary. If there is no expected difference in off mode power and standby mode power, let $P_{W,OFF} = P_{W,SB}$, in which case no separate measurement of off mode power is necessary.

9.0 Nomenclature. Nomenclature shall include the nomenclature specified in section 10 of ANSI/ASHRAE Standard 103–1993 and the following additional variables:

Eff_{motor}=Efficiency of power burner motor

PE_{IG}=Electrical power to the interrupted ignition device, kW

$R_{T,a}$=$R_{T,F}$ if flue gas is measured
=$R_{T,S}$ if stack gas is measured

$R_{T,F}$=Ratio of combustion air mass flow rate to stoichiometric air mass flow rate

$R_{T,S}$=Ratio of the sum of combustion air and relief air mass flow rate to stoichiometric air mass flow rate

t_{IG}=Electrical interrupted ignition device on-time, min.

$T_{a,SS,X}$=$T_{F,SS,X}$ if flue gas temperature is measured, °F
=$T_{S,SS,X}$ if stack gas temperature is measured, °F

y_{IG}=ratio of electrical interrupted ignition device on-time to average burner on-time

y_P=ratio of power burner combustion blower on-time to average burner on-time

E_{SO} = Average annual electric standby mode and off mode energy consumption, in kilowatt-hours

$P_{W,OFF}$ = Furnace or boiler off mode power, in watts

$P_{W,SB}$ = Furnace or boiler standby mode power, in watts

10.0 Calculation of derived results from test measurements. Calculations shall be as specified in section 11 of ANSI/ASHRAE Standard 103–1993 and the October 24, 1996, Errata Sheet for ASHRAE Standard 103–1993, except for appendices B and C; and as specified in sections 10.1 through 10.8 and Figure 1 of this appendix.

10.1 *Annual fuel utilization efficiency.* The annual fuel utilization efficiency (AFUE) is as defined in sections 11.2.12 (non-condensing systems), 11.3.12 (condensing systems), 11.4.12 (non-condensing modulating systems) and 11.5.12 (condensing modulating systems) of ANSI/ASHRAE Standard 103–1993, except for the definition for the term $Effy_{HS}$ in the defining equation for AFUE. $Effy_{HS}$ is defined as:

$Effy_{HS}$=heating seasonal efficiency as defined in sections 11.2.11 (non-condensing systems), 11.3.11 (condensing systems), 11.4.11 (non-condensing modulating systems) and 11.5.11 (condensing modulating systems) of ANSI/ASHRAE Standard 103–1993 and is based on the assumptions that all weatherized warm air furnaces or boilers are located out-of-doors, that warm air furnaces which are not weatherized are installed as isolated combustion systems, and that boilers which are not weatherized are installed indoors.

10.2 *National average burner operating hours, average annual fuel energy consumption and average annual auxiliary electrical energy consumption for gas or oil furnaces and boilers.*

10.2.1 *National average number of burner operating hours.* For furnaces and boilers equipped with single stage controls, the national average number of burner operating hours is defined as:

BOH_{SS}=2,080 (0.77) A DHR–2,080 B

where:

2,080=national average heating load hours

0.77=adjustment factor to adjust the calculated design heating requirement and heating load hours to the actual heating load experienced by the heating system

DHR=typical design heating requirements as listed in Table 8 (in unit of kBtu/h) of ANSI/ASHRAE Standard 103–1993, using the proper value of Q_{OUT} defined in 11.2.8.1 of ANSI/ASHRAE Standard 103–1993

A=100,000 / [341,300(y_PPE+$y_{IG}$$PE_{IG}$+yBE)+($Q_{IN}$–$Q_P$)$Effy_{HS}$], for forced draft unit, indoors

=100,000 / [341,300(y_PPE Eff_{motor}+$y_{IG}$$PE_{IG}$+y BE)+($Q_{IN}$–$Q_P$)$Effy_{HS}$], for forced draft unit, ICS,

=100,000 / [341,300(y_PPE(1–Eff_{motor})+$y_{IG}$$PE_{IG}$+y BE)+($Q_{IN}$–$Q_P$)$Effy_{HS}$], for induced draft unit, indoors, and

=100,000 / [341,300($y_{IG}$$PE_{IG}$+yBE)+($Q_{IN}$–$Q_P$)$Effy_{HS}$], for induced draft unit, ICS

B=2 Q_P($Effy_{HS}$)(A) / 100,000

where:

Eff_{motor}=Power burner motor efficiency provided by manufacturer,

=0.50, an assumed default power burner efficiency if not provided by manufacturer.

100,000=factor that accounts for percent and kBtu

PE=burner electrical power input at full-load steady-state operation, including electrical ignition device if energized, as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103–1993

y_P=ratio of induced or forced draft blower on-time to average burner on-time, as follows:

1 for units without post purge;

1+(t_P/3.87) for single stage furnaces with post purge;

1+(t_P/10) for two-stage and step modulating furnaces with post purge;

1+(t_P/9.68) for single stage boilers with post purge; or

1+(t_P/15) for two stage and step modulating boilers with post purge.

PE_{IG}=electrical input rate to the interrupted ignition device on burner (if employed), as defined in 8.1 of this appendix

y_{IG}=ratio of burner interrupted ignition device on-time to average burner on-time, as follows:

0 for burners not equipped with interrupted ignition device;

(t_{IG}/3.87) for single stage furnaces;

(t_{IG}/10) for two-stage and step modulating furnaces;

(t_{IG}/9.68) for single stage boilers; or

(t_{IG}/15) for two stage and step modulating boilers.

t_{IG}=on-time of the burner interrupted ignition device, as defined in 8.1 of this appendix

t_P=post purge time as defined in 8.2 (furnace) or 8.4 (boiler) of this appendix

=0 if t_P is equal to or less than 30 second.

y=ratio of blower or pump on-time to average burner on-time, as follows:

1 for furnaces without fan delay;

1 for boilers without a pump delay;

1+(t^+—t^-)/3.87 for single stage furnaces with fan delay;

1+(t^+—t^-)/10 for two-stage and step modulating furnaces with fan delay;

1+(t^+/9.68) for single stage boilers with pump delay; or

1+(t^+/15) for two stage and step modulating boilers with pump delay.

BE=circulating air fan or water pump electrical energy input rate at full load steady-state operation, as defined in ANSI/ASHRAE Standard 103–1993

Q_{IN}=as defined in 11.2.8.1 of ANSI/ASHRAE Standard 103–1993

Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993

$Effy_{HS}$=as defined in 11.2.11 (non-condensing systems) or 11.3.11.3 (condensing systems) of ANSI/ASHRAE Standard 103–1993, percent, and calculated on the basis of:

ICS installation, for non-weatherized warm air furnaces;

indoor installation, for non-weatherized boilers; or

outdoor installation, for furnaces and boilers that are weatherized.

2=ratio of the average length of the heating season in hours to the average heating load hours

t^+=as defined in 9.5.1.2 of ANSI/ASHRAE Standard 103–1993 or 8.4 of this appendix

t^-=as defined in 9.6.1 of ANSI/ASHRAE Standard 103–1993

10.2.1.1 For furnaces and boilers equipped with two stage or step modulating controls the average annual energy used during the heating season, E_M, is defined as:

E_M=($Q_{IN}-Q_P$) BOH_{SS}+(8,760−4,600)Q_P

where:

Q_{IN}=as defined in 11.4.8.1.1 of ANSI/ASHRAE Standard 103–1993

Q_P=as defined in 11.4.12 of ANSI/ASHRAE Standard 103–1993

BOH_{SS}=as defined in section 10.2.1 of this appendix, in which the weighted $Effy_{HS}$ as defined in 11.4.11.3 or 11.5.11.3 of ANSI/ASHRAE Standard 103–1993 is used for calculating the values of A and B, the term DHR is based on the value of Q_{OUT} defined in 11.4.8.1.1 or 11.5.8.1.1 of ANSI/ASHRAE Standard 103–1993, and the term

$(y_P PE+y_{IG} PE_{IG}+yBE)$ in the factor A is increased by the factor R, which is defined as:

R=2.3 for two stage controls
=2.3 for step modulating controls when the ratio of minimum-to-maximum output is greater than or equal to 0.5
=3.0 for step modulating controls when the ratio of minimum-to-maximum output is less than 0.5

$A=100{,}000/[341{,}300(y_P PE+y_{IG} PE_{IG}+y\ BE)\ R+(Q_{IN}-Q_P)\ Effy_{HS}]$, for forced draft unit, indoors
$=100{,}000/[341{,}300(y_P PE\ Eff_{motor}+y_{IG} PE_{IG}+y\ BE)\ R+(Q_{IN}-Q_P) Effy_{HS}]$, for forced draft unit, ICS,
$=100{,}000/[341{,}300(y_P PE(1-Eff_{motor})+y_{IG} PE_{IG}+y\ BE)\ R+(Q_{IN}-Q_P)\ Effy_{HS}]$, for induced draft unit, indoors, and
$=100{,}000/[341{,}300(y_{IG} PE_{IG}+y\ BE)\ R+(Q_{IN}-Q_P)\ Effy_{HS}]$, for induced draft unit, ICS

where:

Eff_{motor}=Power burner motor efficiency provided by manufacturer,
=0.50, an assumed default power burner efficiency if none provided by manufacturer.

$Effy_{HS}$=as defined in 11.4.11.3 or 11.5.11.3 of ANSI/ASHRAE Standard 103–1993, and calculated on the basis of:
—ICS installation, for non-weatherized warm air furnaces
—indoor installation, for non-weatherized boilers
—outdoor installation, for furnaces and boilers that are weatherized

8,760=total number of hours per year
4,600=as specified in 11.4.12 of ANSI/ASHRAE Standard 103–1993

10.2.1.2 For furnaces and boilers equipped with two stage or step modulating controls the national average number of burner operating hours at the reduced operating mode is defined as:

$BOH_R=X_R E_M/Q_{IN,R}$

where:

X_R=as defined in 11.4.8.7 of ANSI/ASHRAE Standard 103–1993
E_M=as defined in section 10.2.1.1 of this appendix
$Q_{IN,R}$=as defined in 11.4.8.1.2 of ANSI/ASHRAE Standard 103–1993

10.2.1.3 For furnaces and boilers equipped with two stage controls the national average number of burner operating hours at the maximum operating mode (BOH_H) is defined as:

$BOH_H=X_H E_M/Q_{IN}$

where:

X_H=as defined in 11.4.8.6 of ANSI/ASHRAE Standard 103–1993
E_M=as defined in section 10.2.1.1 of this appendix
Q_{IN}=as defined in 11.4.8.1.1 of ANSI/ASHRAE Standard 103–1993

10.2.1.4 For furnaces and boilers equipped with step modulating controls the national average number of burner operating hours at the modulating operating mode (BOH_M) is defined as:

$BOH_M=X_H E_M/Q_{IN,M}$

where:

X_H=as defined in 11.4.8.6 of ANSI/ASHRAE Standard 103–1993
E_M=as defined in section 10.2.1.1 of this appendix
$Q_{IN,M}=Q_{OUT,M}/(Effy_{SS,M}/100)$
$Q_{OUT,M}$=as defined in 11.4.8.10 or 11.5.8.10 of ANSI/ASHRAE Standard 103–1993, as appropriate
$Effy_{SS,M}$=as defined in 11.4.8.8 or 11.5.8.8 of ANSI/ASHRAE Standard 103–1993, as appropriate, in percent
100=factor that accounts for percent

10.2.2 *Average annual fuel energy consumption for gas or oil fueled furnaces or boilers.* For furnaces or boilers equipped with single stage controls the average annual fuel energy consumption (E_F) is expressed in Btu per year and defined as:

$E_F=BOH_{SS}(Q_{IN}-Q_P)+8{,}760\ Q_P$

where:

BOH_{SS}=as defined in 10.2.1 of this appendix
Q_{IN}=as defined in 11.2.8.1 of ANSI/ASHRAE Standard 103–1993
Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993
8,760=as specified in 10.2.1 of this appendix

10.2.2.1 For furnaces or boilers equipped with either two stage or step modulating controls E_F is defined as:

$E_F=E_M + 4{,}600Q_P$

where:

E_M=as defined in 10.2.1.1 of this appendix
4,600=as specified in 11.4.12 of ANSI/ASHRAE Standard 103–1993
Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993

10.2.3 Average annual auxiliary electrical energy consumption for gas or oil-fueled furnaces or boilers. For furnaces and boilers equipped with single-stage controls, the average annual auxiliary electrical consumption (E_{AE}) is expressed in kilowatt-hours and defined as:

$E_{AE} = BOH_{SS}(y_P PE + y_{IG} PE_{IG} + yBE) + E_{SO}$

Where:

BOH_{SS} = as defined in 10.2.1 of this appendix
PE = as defined in 10.2.1 of this appendix
y_P = as defined in 10.2.1 of this appendix
y_{IG} = as defined in 10.2.1 of this appendix
PE_{IG} = as defined in 10.2.1 of this appendix
y = as defined in 10.2.1 of this appendix

BE = as defined in 10.2.1 of this appendix
E_{SO} = as defined in 10.9 of this appendix.

10.2.3.1 For furnaces or boilers equipped with two-stage controls, E_{AE} is defined as:

$$E_{AE} = BOH_R\,(y_P PE_R + y_{IG} PE_{IG} + yBE_R) + BOH_H\,(y_P PE_H + y_{IG} PE_{IG} + y\,BE_H) + E_{SO}$$

Where:

BOH_R = as defined in 10.2.1.2 of this appendix
y_P = as defined in 10.2.1 of this appendix
PE_R = as defined in 9.1.2.2 and measured at the reduced fuel input rate of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* § 430.3)
y_{IG} = as defined in 10.2.1 of this appendix
PE_{IG} = as defined in 10.2.1 of this appendix
y = as defined in 10.2.1 of this appendix
BE_R = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* § 430.3) measured at the reduced fuel input rate
BOH_H = as defined in 10.2.1.3 of this appendix
PE_H = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* § 430.3) measured at the maximum fuel input rate
BE_H = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* § 430.3) measured at the maximum fuel input rate
E_{SO} = as defined in 10.9 of this appendix.

10.2.3.2 For furnaces or boilers equipped with step-modulating controls, E_{AE} is defined as:

$$E_{AE} = BOH_R\,(y_P\,PE_R + y_{IG} PE_{IG} + yBE_R) + BOH_M\,(y_P PE_H + y_{IG} PE_{IG} + y\,BE_H) + E_{SO}$$

Where:

BOH_R = as defined in 10.2.1.2 of this appendix
y_P = as defined in 10.2.1 of this appendix
PE_R = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* § 430.3), measured at the reduced fuel input rate
y_{IG} = as defined in 10.2.1 of this appendix
PE_{IG} = as defined in 10.2.1 of this appendix
y = as defined in 10.2.1. of this appendix
BE_R = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* § 430.3) measured at the reduced fuel input rate
BOH_M = as defined in 10.2.1.4 of this appendix
PE_H = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* § 430.3) measured at the maximum fuel input rate
BE_H = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* § 430.3) measured at the maximum fuel input rate
E_{SO} = as defined in 10.9 of this appendix.

10.3 Average annual electric energy consumption for electric furnaces or boilers.

$$E_E = 100(2{,}080)(0.77)DHR/(3.412\ AFUE) + E_{SO}$$

Where:

100 = to express a percent as a decimal
2,080 = as specified in 10.2.1 of this appendix
0.77 = as specified in 10.2.1 of this appendix
DHR = as defined in 10.2.1 of this appendix
3.412 = conversion to express energy in terms of watt-hours instead of Btu
AFUE = as defined in 11.1 of ANSI/ASHRAE Standard 103—1993 (incorporated by reference, *see* § 430.3), in percent, and calculated on the basis of: ICS installation, for non-weatherized warm air furnaces; indoor installation, for non-weatherized boilers; or outdoor installation, for furnaces and boilers that are weatherized.
E_{SO} = as defined in 10.9 of this appendix.

10.4 *Energy factor.*

10.4.1 *Energy factor for gas or oil furnaces and boilers.* Calculate the energy factor, EF, for gas or oil furnaces and boilers defined as, in percent:

$$EF = \frac{\left(E_F - 4{,}600\ Q_P\right) Effy_{HS}}{E_F + 3{,}412\ E_{AE}}$$

where:

E_F=average annual fuel consumption as defined in 10.2.2 of this appendix.
E_{AE}=as defined in 10.2.3 of this appendix.
$Effy_{HS}$=Annual Fuel Utilization Efficiency as defined in 11.2.11, 11.3.11, 11.4.11 or 11.5.11 of ANSI/ASHRAE Standard 103–1993, in percent, and calculated on the basis of:
ICS installation, for non-weatherized warm air furnaces;
indoor installation, for non-weatherized boilers; or
outdoor installation, for furnaces and boilers that are weatherized.
3,412=conversion factor from kilowatt to Btu/h

10.4.2 *Energy factor for electric furnaces and boilers.* The energy factor, EF, for electric furnaces and boilers is defined as:

EF=AFUE

where:

AFUE=Annual Fuel Utilization Efficiency as defined in section 10.3 of this appendix, in percent

10.5 *Average annual energy consumption for furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.*

10.5.1 *Average annual fuel energy consumption for gas or oil-fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For gas or oil-fueled furnaces and boilers the average annual fuel energy consumption for a specific geographic region and a specific typical design heating requirement (E_{FR}) is expressed in Btu per year and defined as:

$E_{FR}=(E_F - 8,760\ Q_P)(HLH/2,080)+8,760\ Q_P$

where:

E_F=as defined in 10.2.2 of this appendix
8,760=as specified in 10.2.1 of this appendix
Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993
HLH=heating load hours for a specific geographic region determined from the heating load hour map in Figure 1 of this appendix
2,080=as defined in 10.2.1 of this appendix

10.5.2 Average annual auxiliary electrical energy consumption for gas or oil-fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements. For gas or oil-fueled furnaces and boilers, the average annual auxiliary electrical energy consumption for a specific geographic region and a specific typical design heating requirement (E_{AER}) is expressed in kilowatt-hours and defined as:

$E_{AER} = (E_{AE} - E_{SO})\ (HLH/2080) + E_{SOR}$

Where:

E_{AE} = as defined in 10.2.3 of this appendix
E_{SO} = as defined in 10.9 of this appendix
HLH = as defined in 10.5.1 of this appendix
2,080 = as specified in 10.2.1 of this appendix
E_{SOR} = as specified in 10.5.3 of this appendix.

10.5.3 Average annual electric energy consumption for electric furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements. For electric furnaces and boilers, the average annual electric energy consumption for a specific geographic region and a specific typical design heating requirement (E_{ER}) is expressed in kilowatt-hours and defined as:

E_{ER} = 100(0.77) DHR HLH/(3.412 AFUE) + E_{SOR}

Where:

100 = as specified in 10.3 of this appendix
0.77 = as specified in 10.2.1 of this appendix
DHR = as defined in 10.2.1 of this appendix
HLH = as defined in 10.5.1 of this appendix
3.412 = as specified in 10.3 of this appendix
AFUE = as defined in 10.3 of this appendix
E_{SOR} = E_{SO} as defined in 10.9 of this appendix, except that in the equation for E_{SO}, the term BOH is multiplied by the expression (HLH/2080) to get the appropriate regional accounting of standby mode and off mode loss.

10.6 *Annual energy consumption for mobile home furnaces*

10.6.1 *National average number of burner operating hours for mobile home furnaces (BOH_{SS}).* BOH_{SS} is the same as in 10.2.1 of this appendix, except that the value of $Effy_{HS}$ in the calculation of the burner operating hours, BOH_{SS}, is calculated on the basis of a direct vent unit with system number 9 or 10.

10.6.2 *Average annual fuel energy for mobile home furnaces (E_F).* E_F is same as in 10.2.2 of this appendix except that the burner operating hours, BOH_{SS}, is calculated as specified in 10.6.1 of this appendix.

10.6.3 *Average annual auxiliary electrical energy consumption for mobile home furnaces (E_{AE}).* E_{AE} is the same as in 10.2.3 of this appendix, except that the burner operating hours, BOH_{SS}, is calculated as specified in 10.6.1 of this appendix.

10.7 *Calculation of sales weighted average annual energy consumption for mobile home furnaces.* In order to reflect the distribution of mobile homes to geographical regions with average HLH_{MHF} value different from 2,080, adjust the annual fossil fuel and auxiliary electrical energy consumption values for mobile home furnaces using the following adjustment calculations.

10.7.1 For mobile home furnaces the sales weighted average annual fossil fuel energy consumption is expressed in Btu per year and defined as:

$E_{F,MHF}=(E_F - 8,760\ Q_P)HLH_{MHF}/2,080+8,760\ Q_P$

where:

E_F=as defined in 10.6.2 of this appendix
8,760=as specified in 10.2.1 of this appendix
Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993
HLH_{MHF}=1880, sales weighted average heating load hours for mobile home furnaces
2,080=as specified in 10.2.1 of this appendix

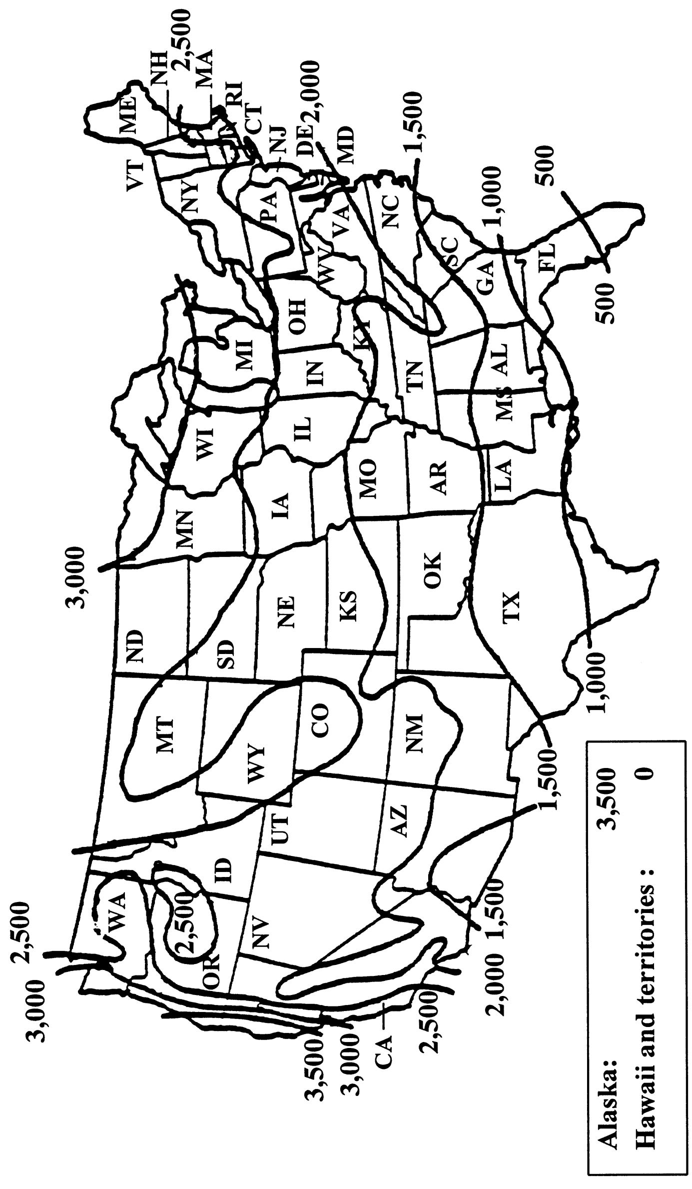
10.7.2 For mobile home furnaces the sales weighted average annual auxiliary electrical energy consumption is expressed in kilowatt-hours and defined as:

$E_{AE,MHF}=E_{AE}HLH_{MHF}/2,080$

where:

E_{AE}=as defined in 10.6.3 of this appendix
HLH_{MHF}=as defined in 10.7.1 of this appendix
2,080=as specified in 10.2.1 of this appendix

10.8 *Direct determination of off-cycle losses for furnaces and boilers equipped with thermal stack dampers.* [Reserved.]



This map is reasonably accurate for most parts of the United States but is necessarily generalized, and consequently not too accurate in mountainous regions, particularly in the rockies.

FIGURE 1- HEATING LOAD HOURS (HLH) FOR THE UNITED STATES

10.9 Average annual electrical standby mode and off mode energy consumption. Calculate the annual electrical standby mode and off mode energy consumption (E_{SO}) in kilowatt-hours, defined as:

$$E_{SO} = ((P_{W,SB} * (4160 - BOH)) + (P_{W,OFF} * 4600)) * K$$

Where:

$P_{W,SB}$ = furnace or boiler standby mode power, in watts, as measured in Section 8.6

4,160 = average heating season hours per year

$P_{W,OFF}$ = furnace or boiler off mode power, in watts, as measured in Section 8.6

4,600 = average non-heating season hours per year

K = 0.001 kWh/Wh, conversion factor for watt-hours to kilowatt-hours

BOH = total burner operating hours as calculated in section 10.2 for gas or oil-fueled furnaces or boilers. Where for gas or oil-fueled furnaces and boilers equipped with single-stage controls, BOH = BOH_{SS}; for gas or oil-fueled furnaces and boilers equipped with two-stage controls, BOH = (BOH_R + BOH_H); and for gas or oil-fueled furnaces and boilers equipped with step-modulating controls, BOH = (BOH_R + BOH_M). For electric furnaces and boilers, BOH = 100(2080)(0.77)DHR/(E_{in} 3.412)(AFUE))

Where:

100 = to express a percent as a decimal

2,080 = as specified in 10.2.1 of this appendix

0.77 = as specified in 10.2.1 of this appendix

DHR = as defined in 10.2.1 of this appendix

3.412 = conversion to express energy in terms of KBtu instead of kilowatt-hours

AFUE = as defined in 11.1 of ANSI/ASHRAE Standard 103—1993 (incorporated by reference, *see* § 430.3) in percent

E_{in} = Steady-state electric rated power, in kilowatts, from section 9.3 of ANSI/ ASHRAE Standard 103—1993 (incorporated by reference, *see* § 430.3).

[62 FR 26157, May 12, 1997, as amended at 62 FR 53510, Oct. 14, 1997; 75 FR 64631, Oct. 20, 2010; 76 FR 37546, June 27, 2011]

Appendix O to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Vented Home Heating Equipment

1.0 Definitions

1.1 ‘‘Air shutter’’ means an adjustable device for varying the size of the primary air inlet(s) to the combustion chamber power burner.

1.2 ‘‘Air tube’’ means a tube which carries combustion air from the burner fan to the burner nozzle for combustion.

1.3 ‘‘Barometic draft regulator or barometric damper’’ means a mechanical device designed to maintain a constant draft in a vented heater.

1.4 ‘‘Draft hood’’ means an external device which performs the same function as an integral draft diverter, as defined in section 1.17 of this appendix.

1.5 ‘‘Electro-mechanical stack damper’’ means a type of stack damper which is operated by electrical and/or mechanical means.

1.6 ‘‘Excess air’’ means air which passes through the combustion chamber and the vented heater flues in excess of that which is theoretically required for complete combustion.

1.7 ‘‘Flue’’ means a conduit between the flue outlet of a vented heater and the integral draft diverter, draft hood, barometric damper or vent terminal through which the flue gases pass prior to the point of draft relief.

1.8 ‘‘Flue damper’’ means a device installed between the furnace and the integral draft diverter, draft hood, barometric draft regulator, or vent terminal which is not equipped with a draft control device, designed to open the venting system when the appliance is in operation and to close the venting system when the appliance is in a standby condition.

1.9 ‘‘Flue gases’’ means reaction products resulting from the combustion of a fuel with the oxygen of the air, including the inerts and any excess air.

1.10 ‘‘Flue losses’’ means the sum of sensible and latent heat losses above room temperature of the flue gases leaving a vented heater.

1.11 ‘‘Flue outlet’’ means the opening provided in a vented heater for the exhaust of the flue gases from the combustion chamber.

1.12 ‘‘Heat input’’ (Q_{in}) means the rate of energy supplied in a fuel to a vented heater operating under steady-state conditions, expressed in Btu's per hour. It includes any input energy to the pilot light and is obtained by multiplying the measured rate of fuel consumption by the measured higher heating value of the fuel.

1.13 ‘‘Heating capacity’’ (Q_{out}) means the rate of useful heat output from a vented heater, operating under steady-state conditions, expressed in Btu's per hour. For room and wall heaters, it is obtained by multiplying the ‘‘heat input’’ (Q_{in}) by the steady-state efficency (η_{ss}) divided by 100. For floor furnaces, it is obtained by multiplying (A) the ‘‘heat input’’ (Q_{in}) by (B) the steady-state efficiency divided by 100, minus the quantity (2.8) (L_j) divided by 100, where L_j is the jacket loss as determined in section 3.2 of this appendix.

1.14 ‘‘Higher heating value’’ (HHV) means the heat produced per unit of fuel when complete combustion takes place at constant pressure and the products of combustion are cooled to the initial temperature of the fuel and air and when the water vapor formed during combustion is condensed. The higher heating value is usually expressed in Btu's per pound, Btu's per cubic foot for gaseous fuel, or Btu's per gallon for liquid fuel.

1.15 ‘‘Induced draft’’ means a method of drawing air into the combustion chamber by mechanical means.

1.16 ‘‘Infiltration parameter’’ means that portion of unconditioned outside air drawn into the heated space as a consequence of loss of conditioned air through the exhaust system of a vented heater.

1.17 ‘‘Integral draft diverter’’ means a device which is an integral part of a vented heater, designed to: (1) Provide for the exhaust of the products of combustion in the event of no draft, back draft, or stoppage beyond the draft diverter, (2) prevent a back draft from entering the vented heater, and (3) neutralize the stack action of the chimney or gas vent upon the operation of the vented heater.

1.18 "Manually controlled vented heaters" means either gas or oil fueled vented heaters equipped without thermostats.

1.19 "Modulating control" means either a step-modulating or two-stage control.

1.20 "Power burner" means a vented heater burner which supplies air for combustion at a pressure exceeding atmospheric pressure, or a burner which depends on the draft induced by a fan incorporated in the furnace for proper operation.

1.21 "Reduced heat input rate" means the factory adjusted lowest reduced heat input rate for vented home heating equipment equipped with either two stage thermostats or step-modulating thermostats.

1.22 "Single stage thermostat" means a thermostat that cycles a burner at the maximum heat input rate and off.

1.23 "Stack" means the portion of the exhaust system downstream of the integral draft diverter, draft hood or barometric draft regulator.

1.24 "Stack damper" means a device installed downstream of the integral draft diverter, draft hood, or barometric draft regulator, designed to open the venting system when the appliance is in operation and to close off the venting system when the appliance is in the standby condition.

1.25 "Stack gases" means the flue gases combined with dilution air that enters at the integral draft diverter, draft hood or barometric draft regulator.

1.26 "Steady-state conditions for vented home heating equipment" means equilibrium conditions as indicated by temperature variations of not more than 5 °F (2.8C) in the flue gas temperature for units equipped with draft hoods, barometric draft regulators or direct vent systems, in three successive readings taken 15 minutes apart or not more than 3 °F (1.7C) in the stack gas temperature for units equipped with integral draft diverters in three successive readings taken 15 minutes apart.

1.27 "Step-modulating control" means a control that either cycles off and on at the low input if the heating load is light, or gradually, increases the heat input to meet any higher heating load that cannot be met with the low firing rate.

1.28 "Thermal stack damper" means a type of stack damper which is dependent for operation exclusively upon the direct conversion of thermal energy of the stack gases into movement of the damper plate.

1.29 "Two stage control" means a control that either cycles a burner at the reduced heat input rate and off or cycles a burner at the maximum heat input rate and off.

1.30 "Vaporizing-type oil burner" means a device with an oil vaporizing bowl or other receptacle designed to operate by vaporizing liquid fuel oil by the heat of combustion and mixing the vaporized fuel with air.

1.31 "Vent/air intake terminal" means a device which is located on the outside of a building and is connected to a vented heater by a system of conduits. It is composed of an air intake terminal through which the air for combustion is taken from the outside atmosphere and a vent terminal from which flue gases are discharged.

1.32 "Vent limiter" means a device which limits the flow of air from the atmospheric diaphragm chamber of a gas pressure regulator to the atmosphere. A vent limiter may be a limiting orifice or other limiting device.

1.33 "Vent pipe" means the passages and conduits in a direct vent system through which gases pass from the combustion chamber to the outdoor air.

2.0 Testing conditions.

2.1 *Installation of test unit.*

2.1.1 *Vented wall furnaces (including direct vent systems).* Install gas fueled vented wall furnaces for test as specified in sections 2.1.3 and 2.1.4 of ANSI Z21.49–1975. Install gas fueled wall furnaces with direct vent systems for test as described in sections 2.1.3 and 2.1.4 of ANSI Z21.44–1973. Install oil fueled vented wall furnaces as specified in UL–730–1974, section 33. Install oil fueled vented wall furnaces with direct vent systems as specified in UL–730–1974, section 34.

2.1.2 *Vented floor furnaces.* Install vented floor furnaces for test as specified in sections 35.1 through 35.5 of UL–729–1976.

2.1.3 *Vented room heaters.* Install in accordance with manufacturer's instructions.

2.2 *Flue and stack requirements.*

2.2.1 *Gas fueled vented home heating equipment employing integral draft diverters and draft hoods (excluding direct vent systems).* Attach to, and vertically above the outlet of gas fueled vented home heating equipment employing draft diverters or draft hoods with vertically discharging outlets, a five (5) foot long test stack having a cross sectional area the same size as the draft diverter outlet.

Attach to the outlet of vented heaters having a horizontally discharging draft diverter or draft hood outlet a 90 degree elbow, and a five (5) foot long vertical test stack. A horizontal section of pipe may be used on the floor furnace between the diverter and the elbow if necessary to clear any framing used in the installation. Use the minimum length of pipe possible for this section. Use stack, elbow, and horizontal section with same cross sectional area as the diverter outlet.

2.2.2 *Oil fueled vented home heating equipment (excluding direct vent systems).* Use flue connections for oil fueled vented floor furnaces as specified in section 35 of UL 729–1976, sections 34.10 through 34.18 of UL 730–1974 for oil fueled vented wall furnaces and sections 36.2 and 36.3 of UL 896–1973 for oil fueled vented room heaters.

2.2.3 *Direct vent systems.* Have the exhaust/air intake system supplied by the manufacturer in place during all tests. Test units intended for installation with a variety of vent pipe lengths with the minimum length recommended by the manufacturer. Do not connect a heater employing a direct vent system to a chimney or induced draft source. Vent the gas solely on the provision for venting incorporated in the heater and the vent/air intake system supplied with it.

2.3 *Fuel supply.*

2.3.1 *Natural gas.* For a vented heater utilizing natural gas, maintain the gas supply to the unit under test at a normal inlet test pressure immediately ahead of all controls at 7 to 10 inches water column. Maintain the regulator outlet pressure at normal test pressure approximately at that recommended by the manufacturer. Use natural gas having a specific gravity of approximately 0.65 and a higher heating value within ±5 percent of 1,025 Btu's per standard cubic foot. Determine the actual higher heating value in Btu's per standard cubic foot for the natural gas to be used in the test with an error no greater than one percent.

2.3.2 *Propane gas.* For a vented heater utilizing propane gas, maintain the gas supply to the unit under test at a normal inlet pressure of 11 to 13 inches water column and a specific gravity of approximately 1.53. Maintain the regulator outlet pressure, on units so equipped, approximately at that recommended by the manufacturer. Use propane having a specific gravity of approximately 1.53 and a higher heating value within ±5 percent of 2,500 Btu's per standard cubic foot. Determine the actual higher heating value in Btu's per standard cubic foot for the propane to be used in the test with an error no greater than one percent.

2.3.3 *Other test gas.* Use other test gases with characteristics as described in section 2.2, table VII, of ANSI Standard Z21.11.1–1974. Use gases with a measured higher heating value within ±5 percent of the values specified in the above ANSI standard. Determine the actual higher heating value of the gas used in the test with an error no greater than one percent.

2.3.4 *Oil supply.* For a vented heater utilizing fuel oil, use No. 1, fuel oil (kerosene) for vaporizing-type burners and either No. 1 or No. 2 fuel oil, as specified by the manufacturer, for mechanical atomizing type burners. Use No. 1 fuel oil with a viscosity meeting the specifications as specified in UL–730–1974, section 36.9. Use test fuel conforming to the specifications given in tables 2 and 3 of ANSI Standard Z91.1–1972 for No. 1 and No. 2 fuel oil. Measure the higher heating value of the test fuel with an error no greater than one percent.

2.3.5 *Electrical supply.* For auxiliary electric components of a vented heater, maintain the electrical supply to the test unit within one percent of the nameplate voltage for the entire test cycle. If a voltage range is used for nameplate voltage, maintain the electrical supply within one percent of the midpoint of the nameplate voltage range.

2.4 *Burner adjustments.*

2.4.1 *Gas burner adjustments.* Adjust the burners of gas fueled vented heaters to their maximum Btu ratings at the test pressure specified in section 2.3 of this appendix. Correct the burner volumetric flow rate to 60 °F (15.6C) and 30 inches of mercury barometric pressure, set the fuel flow rate to obtain a heat rate of within ±2 percent of the hourly Btu rating specified by the manufacturer as measured after 15 minutes of operation starting with all parts of the vented heater at room temperature. Set the primary air shutters in accordance with the manufacturer's recommendations to give a good flame at this adjustment. Do not allow the deposit of carbon during any test specified herein.

If a vent limiting means is provided on a gas pressure regulator, have it in place during all tests.

For gas fueled heaters with modulating controls adjust the controls to operate the heater at the maximum fuel input rate. Set the thermostat control to the maximum setting. Start the heater by turning the safety control valve to the ''on'' position. In order to prevent modulation of the burner at maximum input, place the thermostat sensing element in a temperature control bath which is held at a temperature below the maximum set point temperature of the control.

For gas fueled heaters with modulating controls adjust the controls to operate the heater at the reduced fuel input rate. Set the thermostat control to the minimum setting. Start the heater by turning the safety control valve to the ''on'' position. If ambient test room temperature is above the lowest control set point temperature, initiate burner operation by placing the thermostat sensing element in a temperature control bath that is held at a temperature below the minimum set point temperature of the control.

2.4.2 *Oil burner adjustments.* Adjust the burners of oil fueled vented heaters to give the CO_2 reading recommended by the manufacturer and an hourly Btu input, during the steady-state performance test described below, which is within ±2 percent of the heater manufacturer's specified normal hourly Btu input rating. On units employing a power burner do not allow smoke in the flue to exceed a No. 1 smoke during the steady-state performance test as measured by the procedure in ANSI Standard Z11.182–1965 (R1971) (ASTM D 2156–65 (1970)). If, on units employing a power burner, the smoke in the flue exceeds a No. 1 smoke during the steady-state test, readjust the burner to give a lower smoke reading, and, if necessary a lower CO_2 reading, and start all tests over. Maintain the average draft over the fire and in the flue during the steady-state performance test at that recommended by the manufacturer within ±0.005 inches of water gauge. Do not make additional adjustments to the burner during the required series of performance tests. The instruments and measuring apparatus for this test are described in section 6.3 of ANSI standard Z91.1–1972.

2.5 *Circulating air adjustments.*

2.5.1 *Forced air vented wall furnaces (including direct vent systems).* During tests maintain the air flow through the heater as specified by the manufacturer and operate the vented heater with the outlet air temperature between 80 °F and 130 °F above room temperature. If adjustable air discharge registers are provided, adjust them so as to provide the maximum possible air restriction. Measure air discharge temperature as specified in section 2.14 of ANSI Z21.49–1975.

2.5.2 *Fan type vented room heaters and floor furnaces.* During tests on fan type furnaces and heaters, adjust the air flow through the heater as specified by the manufacturer. If adjustable air discharge registers are provided, adjust them to provide the maximum possible air restriction.

2.6 *Location of temperature measuring instrumentation.*

2.6.1 *Gas fueled vented home heating equipment (including direct vent systems).* For units employing an integral draft diverter, install nine thermocouples, wired in parallel, in a horizontal plane in the five foot test stack located one foot from the test stack inlet. Equalize the length of all thermocouple leads before paralleling. Locate one thermocouple in the center of the stack. Locate eight thermocouples along imaginary lines intersecting at right angles in this horizontal plane at points one third and two thirds of the distance between the center of the stack and the stack wall.

For units which employ a direct vent system, locate at least one thermocouple at the center of each flue way exiting the heat exchanger. Provide radiation shields if the thermocouples are exposed to burner radiation.

For units which employ a draft hood or units which employ a direct vent system which does not significantly preheat the incoming combustion air, install nine thermocouples, wired in parallel, in a horizontal plane located within 12 inches (304.8 mm) of the heater outlet and upstream of the draft hood on units so equipped. Locate one thermocouple in the center of the pipe and eight thermocouples along imaginary lines intersecting at right angles in this horizontal plane at points one third and two thirds of the distance between the center of the pipe and the pipe wall.

For units which employ direct vent systems that significantly preheat the incoming combustion air, install nine thermocouples, wired in parallel, in a plane parallel to and located within 6 inches (152.4 mm) of the vent/air intake terminal. Equalize the length of all thermocouple leads before paralleling. Locate one thermocouple in the center of the vent pipe and eight thermocouples along imaginary lines intersecting at right angles in this plane at points one third and two thirds of the distance between the center of the flue pipe and the pipe wall.

Use bead-type thermocouples having wire size not greater than No. 24 American Wire Gauge (AWG). If there is a possibility that the thermocouples could receive direct radiation from the fire, install radiation shields on the fire side of the thermocouples only and position the shields so that they do not touch the thermocouple junctions.

Install thermocouples for measuring conditioned warm air temperature as described in ANSI Z21.49–1975, section 2.14. Establish the temperature of the inlet air by means of single No. 24 AWG bead-type thermocouple, suitably shielded from direct radiation and located in the center of the plane of each inlet air opening.

2.6.2 *Oil fueled vented home heating equipment (including direct vent systems).* Install nine thermocouples, wired in parallel and having equal length leads, in a plane perpendicular to the axis of the flue pipe. Locate this plane at the position shown in Figure 34.4 of UL 730–1974, or Figures 35.1 and 35.2 of UL 729–1976 for a single thermocouple, except that on direct vent systems which significantly preheat the incoming combustion air, it shall be located within 6 inches (152.5 mm) of the outlet of the vent/air intake terminal. Locate one thermocouple in the center of the flue pipe and eight thermocouples along imaginary lines intersecting at right angles in this plane at points one third and two thirds of the distance between the center of the pipe and pipe wall.

Use bead-type thermocouples having a wire size not greater than No. 24 AWG. If there is a possibility that the thermocouples could receive direct radiation from the fire, install radiation shields on the fire side of the thermocouples only and position the shields so that they do not touch the thermocouple junctions.

Install thermocouples for measuring the conditioned warm air temperature as described in sections 35.12 through 35.17 of UL 730–1974. Establish the temperature of the inlet air by means of a single No. 24 AWG bead-type thermocouple, suitably shielded from direct radiation and located in the center of the plane of each inlet air opening.

2.7 *Combustion measurement instrumentation.* Analyze the samples of stack and flue gases for vented heaters to determine the concentration by volume of carbon dioxide present in the dry gas with instrumentation which will result in a reading having an accuracy of ±0.1 percentage points.

2.8 *Energy flow instrumentation.* Install one or more instruments, which measure the rate of gas flow or fuel oil supplied to the vented heater, and if appropriate, the electrical energy with an error no greater than one percent.

2.9 *Room ambient temperature.* During the time period required to perform all the testing and measurement procedures specified in section 3.0 of this appendix, maintain the room temperature within ±5 °F (±2.8C) of the value T_{RA} measured during the steady-state performance test. At no time during these tests shall the room temperature exceed 100 °F (37.8C) or fall below 65 °F (18.3C).

Temperature (T_{RA}) shall be the arithmetic average temperature of the test area, determined by measurement with four No. 24 AWG bead-type thermocouples with junctions shielded against radiation, located approximately at 90-degree positions on a circle circumscribing the heater or heater enclosure under test, in a horizontal plane approximately at the vertical midpoint of the appliance or test enclosure, and with the junctions approximately 24 inches from sides of the heater or test enclosure and located so as not to be affected by other than room air. Locate a thermocouple at each elevation of draft relief inlet opening and combustion air inlet opening at a distance of approximately 24 inches from the inlet openings. The temperature of the air for combustion and the air for draft relief shall not differ more than ±5 °F from room temperature as measured above.

2.10 *Equipment used to measure mass flow rate in flue and stack.* The tracer gas chosen for this task should have a density which is less than or approximately equal to the density of air. Use a gas unreactive with the environment to be encountered. Using instrumentation of either the batch or continuous type, measure the concentration of tracer gas with an error no greater than 2 percent of the value of the concentration measured.

3.0 Testing and measurements.

3.1 *Steady-state testing.*

3.1.1 *Gas fueled vented home heating equipment (including direct vent systems).* Set up the vented heater as specified in sections 2.1, 2.2, and 2.3 of this appendix. The draft diverter shall be in the normal open condition and the stack shall not be insulated. (Insulation of the stack is no longer required for the vented heater test.) Begin the steady-state performance test by operating the burner and the circulating air blower, on units so equipped, with the adjustments specified by sections 2.4.1 and 2.5 of this appendix, until steady-state conditions are attained as indicated by a temperature variation of not more than 3 °F (1.7 C) in the stack gas temperature for vented heaters equipped with draft diverters or 5 °F (2.8 C) in the flue gas temperature for vented heaters equipped with either draft hoods or direct vent systems; in three successive readings taken 15 minutes apart.

On units employing draft diverters, measure the room temperature (T_{RA}) as described in section 2.9 of this appendix and measure the steady-state stack gas temperature ($T_{S,SS}$) using the nine thermocouples located in the 5 foot test stack as specified in section 2.6.1 of this appendix. Secure a sample of the stack gases in the plane where $T_{S,SS}$ is measured or within 3.5 feet downstream of this plane. Determine the concentration by volume of carbon dioxide (X_{CO2S}) present in the dry stack gas. If the location of the gas sampling differs from the temperature measurement plane, there shall be no air leaks through the stack between these two locations.

On units employing draft hoods or direct vent systems, measure the room temperature (T_{RA}) as described in section 2.9 of this appendix and measure the steady-state flue gas temperature ($T_{F,SS}$), using the nine thermocouples located in the flue pipe as described in section 2.6.1 of this appendix. Secure a sample of the flue gas in the plane of temperature measurement and determine the concentration by volume of CO_2 (X_{CO2F}) present in dry flue gas. In addition, for units employing draft hoods, secure a sample of the stack gas in a horizontal plane in the five foot test stack located one foot from the test stack inlet; and determine the concentration by volume of CO_2 (X_{CO2S}) present in dry stack gas.

Determine the steady-state heat input rate (Q_{in}) including pilot gas by multiplying the measured higher heating value of the test gas by the steady-state gas input rate corrected to standard conditions of 60 °F and 30 inches of mercury. Use measured values of gas temperature and pressure at the meter and the barometric pressure to correct the metered gas flow rate to standard conditions.

After the above test measurements have been completed on units employing draft diverters, secure a sample of the flue gases at the exit of the heat exchanger(s) and determine the concentration of CO_2 (X_{CO2F}) present. In obtaining this sample of flue gas, move the sampling probe around or use a sample probe with multiple sampling ports in order to assure that an average value is obtained for the CO_2 concentration. For units with multiple heat exchanger outlets, measure the CO_2 concentration in a sample from each outlet to obtain the average CO_2 concentration for the unit. A manifold (parallel connected sampling tubes) may be used to obtain this sample.

For heaters with single stage thermostat control (wall mounted electric thermostats), determine the steady-state efficiency at the maximum fuel input rate as specified in section 2.4 of this appendix.

For gas fueled vented heaters equipped with either two stage thermostats or step-modulating thermostats, determine the steady-state efficiency at the maximum fuel input rate, as specified in section 2.4.1 of this appendix, and at the reduced fuel input rate, as specified in section 2.4.1 of this appendix.

For manually controlled gas fueled vented heaters, with various input rates determine the steady-state efficiency at a fuel input rate that is within ±5 percent of 50 percent of the maximum fuel input rate. If the heater is designed to use a control that precludes operation at other than maximum output (single firing rate) determine the steady state efficiency at the maximum input rate only.

3.1.2 *Oil fueled vented home heating equipment (including direct vent systems).* Set up and adjust the vented heater as specified in sections 2.1, 2.2, and 2.3.4 of this appendix. Begin the steady-state performance test by operating the burner and the circulating air blower, on units so equipped, with the adjustments specified by sections 2.4.2 and 2.5 of this appendix until steady-state conditions are attained as indicated by a temperature variation of not more than 5 °F (2.8 C) in the flue gas temperature in three successive readings taken 15 minutes apart.

Do not allow smoke in the flue, for units equipped with power burners, to exceed a No. 1 smoke during the steady-state performance test as measured by the procedure described in ANSI standard Z11.182–1965 (R1971) (ASTM D 2156–65 (1970)). Maintain the average draft over the fire and in the breeching during the steady-state performance test at that recommended by the manufacturer ±0.005 inches of water gauge.

Measure the room temperature (T_{RA}) as described in section 2.9 of this appendix and measure the steady-state flue gas temperature ($T_{F,SS}$) using nine thermocouples located in the flue pipe as described in section 2.6.2 of this appendix. Secure a sample of the flue gas in the plane of temperature measurement and determine the concentration by volume of CO_2(X_{CO2F}) present in dry flue gas. Measure and record the steady-state heat input rate (Q_{in}).

For manually controlled oil fueled vented heaters, determine the steady-state efficiency at a fuel input rate that is within ±5 percent of 50 percent of the maximum fuel input rate.

3.1.3 *Auxiliary Electric Power Measurement.* Allow the auxiliary electrical system of a gas or oil vented heater to operate for at least five minutes before recording the maximum auxiliary electric power measurement from the wattmeter. Record the maximum electric power (P_E) expressed in kilowatts. For vented heaters with modulating controls, the recorded (P_E) shall be maximum measured electric power multiplied by the following factor (R). For two stage controls, R=1.3. For step modulating controls, R=1.4 when the ratio of minimum-to-maximum fuel input is greater than or equal to 0.7, R=1.7 when the ratio of minimum-to-maximum fuel input is less than 0.7 and greater than or equal to 0.5, and R=2.2 when the ratio of minimum-to-maximum fuel input is less than 0.5.

3.2 *Jacket loss measurement.* Conduct a jacket loss test for vented floor furnaces. Measure the jacket loss (L_j) in accordance with the ANSI standard Z21.48–1976 section 2.12.

3.3 *Measurement of the off-cycle losses for vented heaters equipped with thermal stack dampers.* Install the thermal stack damper according to the manufacturer's instructions. Unless specified otherwise, the thermal stack damper should be at the draft diverter exit collar. Attach a five foot length of bare stack to the outlet of the damper. Install thermocouples as specified in section 2.6.1 of this appendix.

For vented heaters equipped with single stage thermostats, measure the off-cycle losses at the maximum fuel input rate. For vented heaters equipped with two stage thermostats, measure the off-cycle losses at the maximum fuel input rate and at the reduced fuel input rate. For vented heaters equipped with step-modulating thermostats, measure the off-cycle losses at the reduced fuel input rate.

Let the vented heater heat up to a steady-state condition. Feed a tracer gas at a constant metered rate into the stack directly above and within one foot above the stack damper. Record tracer gas flow rate and temperature. Measure the tracer gas concentration in the stack at several locations in a horizontal plane through a cross section of the stack at a point sufficiently above the stack damper to ensure that the tracer gas is well mixed in the stack.

Continuously measure the tracer gas concentration and temperature during a 10 minute cool down period. Shut the burner off and immediately begin measuring tracer gas concentration in the stack, stack temperature, room temperature, and barometric pressure. Record these values as the mid-point of each one-minute interval between burner shut down and ten minutes after burner shut down. Meter response time and sampling delay time shall be considered in timing these measurements.

3.4 *Measurement of the effectiveness of electro-mechanical stack dampers.* For vented heaters equipped with electro-mechanical stack dampers, measure the cross sectional area of the stack (A_s), the net area of the damper plate (A_o), and the angle that the damper plate makes when closed with a plane perpendicular to the axis of the stack (Ω). The net area of the damper plate means the area of the damper plate minus the area of any holes through the damper plate.

3.5 *Pilot light measurement.*

3.5.1 Measure the energy input rate to the pilot light (Q_P) with an error no greater than 3 percent for vented heaters so equipped.

3.5.2 For manually controlled heaters where the pilot light is designed to be turned off by the user when the heater is not in use, that is, turning the control to the OFF position will shut off the gas supply to the burner(s) and to the pilot light, the measurement of Q_P is not needed. This provision applies only if an instruction to turn off the unit is provided on the heater near the gas control valve (e.g. by label) by the manufacturer.

3.6 *Optional procedure for determining* D_P, D_F and D_s *for systems for all types of vented heaters.* For all types of vented heaters, D_P, D_F and D_S can be measured by the following optional cool down test.

Conduct a cool down test by letting the unit heat up until steady-state conditions are reached, as indicated by temperature variation of not more than 5 °F (2.8 °C) in the flue gas temperature in three successive readings taken 15 minutes apart, and then shutting the unit off with the stack or flue damper controls by-passed or adjusted so that the stack or flue damper remains open during the resulting cool down period. If a draft was maintained on oil fueled units in the flue pipe during the steady-state performance test described in section 3.1 of this appendix, maintain the same draft (within a range of −.001 to +.005 inches of water gauge of the average steady-state draft) during this cool down period.

Measure the flue gas mass flow rate ($m_{F,OFF}$) during the cool down test described above at a specific off-period flue gas temperature and corrected to obtain its value at the steady-state flue gas temperature ($T_{F,SS}$), using the procedure described below.

Within one minute after the unit is shut off to start the cool down test for determining D_F, begin feeding a tracer gas into the combustion chamber at a constant flow rate of V_T, and at a point which will allow for the best possible mixing with the air flowing through the chamber. (On units equipped with an oil fired power burner, the best location for injecting this tracer gas appears to be through a hole drilled in the air tube.) Periodically measure the value of V_T with an instantaneously reading flow meter having an accuracy of ±3 percent of the quantity measured. Maintain V_T at less than 1 percent of the air flow rate through the furnace. If a combustible tracer gas is used, there should be a delay period between the time the burner gas is shut off and the time the tracer gas is first injected to prevent ignition of the tracer gas.

Between 5 and 6 minutes after the unit is shut off to start the cool down test, measure at the exit of the heat exchanger the average flue gas temperature, $T^*_{F,Off}$. At the same instant the flue gas temperature is measured, also measure the percent volumetric concentration of tracer gas C_T in the flue gas in the same plane where $T^*_{F,Off}$ is determined. Obtain the concentration of tracer gas using an instrument which will result in an accuracy of ±2 percent in the value of C_T measured. If use of a continuous reading type instrument results in a delay time between drawing of a sample and its analysis, this delay should be taken into account so that the temperature measurement and the measurement of tracer gas concentration coincide. In addition, determine the temperature of the tracer gas entering the flow meter (T_T) and the barometric pressure (P_B).

The rate of the flue gas mass flow through the vented heater and the factors D_P, D_F, and D_S are calculated by the equations in sections 4.5.1 through 4.5.3 of this appendix.

4.0 Calculations.

4.1 *Annual fuel utilization efficiency for gas or oil fueled vented home heating equipment equipped without manual controls and without thermal stack dampers.* The following procedure determines the annual fuel utilization efficiency for gas or oil fueled vented home heating equipment equipped without manual controls and without thermal stack dampers.

4.1.1 *System number.* Obtain the system number from Table 1 of this appendix.

4.1.2 *Off-cycle flue gas draft factor.* Based on the system number, determine the off-cycle flue gas draft factor (D_F) from Table 1 of this appendix.

4.1.3 *Off-cycle stack gas draft factor.* Based on the system number, determine the off-cycle stack gas draft factor (D_s) from Table 1 of this appendix.

4.1.4 *Pilot fraction.* Calculate the pilot fraction (P_F) expressed as a decimal and defined as:

$$P_F = Q_P/Q_{in}$$

where:

Q_P= as defined in 3.5 of this appendix
Q_{in}= as defined in 3.1 of this appendix at the maximum fuel input rate

4.1.5 *Jacket loss for floor furnaces.* Determine the jacket loss (L_j) expressed as a percent and measured in accordance with section 3.2 of this appendix. For other vented heaters L_j=0.0.

4.1.6 *Latent heat loss.* Based on the fuel, obtain the latent heat loss ($L_{L,A}$) from Table 2 of this appendix.

4.1.7 *Ratio of combustion air mass flow rate to stoichiometric air mass flow rate.* Determine the ratio of combustion air mass flow rate to stoichiometric air mass flow rate ($R_{T,F}$), and defined as:

$R_{T,F}$=A+B/X_{CO2F}

where:

A=as determined from Table 2 of this appendix

B=as determined from Table 2 of this appendix

X_{CO2F}=as defined in 3.1 of this appendix

4.1.8 *Ratio of combustion and relief air mass flow rate to stoichiometric air mass flow rate.* For vented heaters equipped with either an integral draft diverter or a drafthood, determine the ratio of combustion and relief air mass flow rate to stoichiometric air mass flow rate ($R_{T,S}$), and defined as:

$R_{T,S}$=A+[B/X_{CO2S}]

where:

A=as determined from Table 2 of this appendix

B=as determined from Table 2 of this appendix

X_{CO2S}=as defined in 3.1 of this appendix

4.1.9 *Sensible heat loss at steady-state operation.* For vented heaters equipped with either an integral draft diverter or a draft hood, determine the sensible heat loss at steady-state operation ($L_{S,SS,A}$) expressed as a percent and defined as:

where:

$L_{S,SS,A}=C(R_{T,S}+D)(T_{S,SS}-T_{RA})$

C=as determined from Table 2 of this appendix

$R_{T,S}$=as defined in 4.1.8 of this appendix

D=as determined from Table 2 of this appendix

$T_{S,SS}$=as defined in 3.1 of this appendix

T_{RA}=as defined in 2.9 of this appendix

For vented heaters equipped without an integral draft diverter, determine ($L_{S,SS,A}$) expressed as a percent and defined as:

$L_{S,SS,A}=C(R_{T,F}+D)(T_{F,SS}-T_{RA})$

where:

C=as determined from Table 2 of this appendix

$R_{T,F}$=as defined in 4.1.7 of this appendix

D=as determined from Table 2 of this appendix

$T_{F,SS}$=as defined in 3.1 of this appendix

T_{RA}=as defined in 2.9 of this appendix

4.1.10 *Steady-state efficiency.* For vented heaters equipped with single stage thermostats, calculate the steady-state efficiency (excluding jacket loss, η_{SS}, expressed in percent and defined as:

$\eta_{SS}=100-L_{L,A}-L_{S,SS,A}$

where:

$L_{L,A}$=as defined in 4.1.6 of this appendix

$L_{S,SS,A}$=as defined in 4.1.9 of this appendix

For vented heaters equipped with either two stage thermostats or with step-modulating thermostats, calculate the steady-state efficiency at the reduced fuel input rate, η_{SS}, L, expressed in percent and defined as:

$\eta_{SS-L}=100-L_{L,A}-L_{S,SS,A}$

where:

$L_{L,A}$=as defined in 4.1.6 of this appendix

$L_{S,SS,A}$=as defined in 4.1.9 of this appendix in which $L_{S,SS,A}$ is determined at the reduced fuel input rate

For vented heaters equipped with two stage thermostats, calculate the steady-state efficiency at the maximum fuel input rate,

η_{SS-H}, expressed in percent and defined as:

$\eta_{SS-H}=100-L_{L,A}-L_{S,SS,A}$

where:

$L_{L,A}$=as defined in 4.1.6 of this appendix

$L_{S,SS,A}$=as defined in 4.1.9 of this appendix in which $L_{S,SS,A}$ is measured at the maximum fuel input rate

For vented heaters equipped with step-modulating thermostats, calculate the weighted-average steady-state efficiency in the modulating mode, η_{SS-MOD}, expressed in percent and defined as:

$$\eta_{SS-MOD}=\left[\eta_{SS-H}-\eta_{SS-L}\right]\left[\frac{T_C-T_{OA*}}{T_C-15}\right]+\eta_{SS-L}$$

where:

η_{SS-H}=as defined in 4.1.10 of this appendix

η_{SS-L}=as defined in 4.1.10 of this appendix

T_{OA*}=average outdoor temperature for vented heaters with step-modulating thermostats operating in the modulating mode and is obtained from Table 3 or Figure 1 of this appendix

T_C=balance point temperature which represents a temperature used to apportion the annual heating load between the reduced input cycling mode and either the modulating mode or maximum input cycling mode and is obtained either from Table 3 of this appendix or calculated by the following equation:

$T_C=65-[(65-15)R]$

where:

65=average outdoor temperature at which a vented heater starts operating
15=national average outdoor design temperature for vented heaters
R=ratio of reduced to maximum heat output rates, as defined in 4.1.13 of this appendix

4.1.11 *Reduced heat output rate.* For vented heaters equipped with either two stage thermostats or step-modulating thermostats, calculate the reduced heat output rate ($Q_{red\text{-}out}$) defined as:

$Q_{red\text{-}out}=\eta_{SS-L}\ Q_{red\text{-}in}$

where:

η_{SS-L}=as defined in 4.1.10 of this appendix
$Q_{red\text{-}in}$=the reduced fuel input rate

4.1.12 *Maximum heat output rate.* For vented heaters equipped with either two stage thermostats or step-modulating thermostas, calculate the maximum heat output rate ($Q_{max\text{-}out}$) defined as:

$Q_{max,out}=h_{SS,H}\ Q_{max,in}$

where:

η_{SS-H}=as defined in 4.1.10 of this appendix
$Q_{max\text{-}in}$=the maximum fuel input rate

4.1.13 *Ratio of reduced to maximum heat output rates.* For vented heaters equipped with either two stage thermostats or step-modulating thermostats, calculate the ratio of reduced to maximum heat output rates (R) expressed as a decimal and defined as:

$R=Q_{red\text{-}out}/Q_{max\text{-}out}$

where:

$Q_{red\text{-}out}$=as defined in 4.1.11 of this appendix
$Q_{max\text{-}out}$=as defined in 4.1.12 of this appendix

4.1.14 *Fraction of heating load at reduced operating mode.* For vented heaters equipped with either two stage thermostats or step-modulating thermostats, determine the fraction of heating load at the reduced operating mode (X_1) expressed as a decimal and listed in Table 3 of this appendix or obtained from Figure 2 of this appendix.

4.1.15 *Fraction of heating load at maximum operating mode or noncycling mode.* For vented heaters equFipped with either two stage thermostats or step-modulating therostats, determine the fraction of heating load at the maximum operating mode or noncycling mode (X_2) expressed as a decimal and listed in Table 3 of this appendix or obtained from Figure 2 of this appendix.

4.1.16 *Weighted-average steady-state efficiency.* For vented heaters equipped with single stage thermostats, the weighted-average steady-state efficiency (η_{SS-WT}) is equal to η_{SS}, as defined in section 4.1.10 of this appendix. For vented heaters equipped with two stage thermostats, η_{SS-WT} is defined as:

$\eta_{SS-WT}=X_1\eta_{SS-L}+X_2\eta_{SS-H}$

where:

X_1=as defined in 4.1.14 of this appendix
η_{SS-L}=as defined in 4.1.10 of this appendix
X_2=as defined in 4.1.15 of this appendix
η_{SS-H}=as defined in 4.1.10 of this appendix

For vented heaters equipped with step-modulating thermostats, η_{SS-WT} is defined as:

$\eta_{SS-WT}=X_1\eta_{SS-L}+X_2\eta_{SS-MOD}$

where:

X_1=as defined in 4.1.14 of this appendix
η_{SS-L}=as defined in 4.1.10 of this appendix
X_2=as defined in 4.1.15 of this appendix
η_{SS-MOD}=as defined in 4.1.10 of this appendix

4.1.17 *Annual fuel utilization efficiency.* Calculate the annual fuel utilization efficiency (AFUE) expressed as percent and defined as:

$AFUE=[0.968\eta_{SS-WT}]-1.78D_F-1.89D_S-129P_F-2.8\ L_J+1.81$

where:

η_{SS-WT}=as defined in 4.1.16 of this appendix
D_F=as defined in 4.1.2 of this appendix
D_S=as defined in 4.1.3 of this appendix
P_F=as defined in 4.1.4 of this appendix
L_J=as defined in 4.1.5 of this appendix

4.2 *Annual fuel utilization efficiency for gas or oil fueled vented home heating equipment equipped with manual controls.* The following procedure determines the annual fuel utilization efficiency for gas or oil fueled vented home heating equipment equipped with manual controls.

4.2.1 *Average ratio of stack gas mass flow rate to flue gas mass flow rate at steady-state operation.* For vented heaters equipped with either direct vents or direct exhaust or are outdoor units, the average ratio of stack gas mass flow rate to flue gas mass flow rate at steady-state operation (S/F) shall be equal to unity. (S/F=1.) For all other types of vented heaters, calculate (S/F) defined as:

$S/F=1.3R_{T,S}/R_{T,F}$

where:

$R_{T,S}$=as defined in 4.1.8 of this appendix with X_{CO2s} measured at 50% fuel input rate
$R_{T,F}$=as defined in 4.1.7 of this appendix with X_{CO2F} measured at 50% fuel input rate

4.2.2 *Multiplication factor for infiltration loss during burner on-cycle.* Calculate the multiplication factor for infiltration loss during burner on-cycle ($K_{I,ON}$) defined as:

$K_{I,ON}=100(0.24)\ (S/F)\ (0.7)\ [1+R_{T,F}(A/F)]/HHV_A$

where:

100=converts a decimal fraction into a percent
0.24=specific heat of air
A/F=stoichiometric air/fuel ratio, determined in accordance with Table 2 of this appendix

S/F=as defined in 4.2.1 of this appendix at 50 percent of rated maximum fuel input
0.7=infiltration parameter
$R_{T,F}$=as defined in 4.1.7 of this appendix
HHV_A=average higher heating value of the test fuel, determined in accordance with Table 2 of this appendix

4.2.3 *On-cycle infiltration heat loss.* Calculate the on-cycle infiltration heat loss ($L_{I,ON}$) expressed as a percent and defined as:

$L_{I,ON}=K_{I,ON}$ (70–45)

where:

$K_{I,ON}$=as defined in 4.2.2 of this appendix
70=average indoor temperature
45=average outdoor temperature

4.2.4 *Weighted-average steady-state efficiency.*

4.2.4.1 For manually controlled heaters with various input rates the weighted average steady-state efficiency (η_{SS-WT}), is determined as follows:

(1) at 50 percent of the maximum fuel input rate as measured in either section 3.1.1 of this appendix for manually controlled gas vented heaters or section 3.1.2 of this appendix for manually controlled oil vented heaters, or

(2) at the minimum fuel input rate as measured in either section 3.1.1 to this appendix for manually controlled gas vented heaters or section 3.1.2 to this appendix for manually controlled oil vented heaters if the design of the heater is such that the ±5 percent of 50 percent of the maximum fuel input rate cannot be set, provided this minimum rate is no greater than ⅔ of maximum input rate of the heater.

4.2.4.2 For manually controlled heater with one single firing rate the weighted average steady-state efficiency is the steady-state efficiency measured at the single firing rate.

4.2.5 *Part-load fuel utilization efficiency.* Calculate the part-load fuel utilization efficiency (η_u) expressed as a percent and defined as:

$\eta_u=\eta_{SS\text{-}WT}-L_{I,ON}$

where:

$\eta_{SS\text{-}WT}$=as defined in 4.2.4 of this appendix
$L_{I,ON}$=as defined in 4.2.3 of this appendix

4.2.6 *Annual Fuel Utilization Efficiency.*

4.2.6.1 For manually controlled vented heaters, calculate the AFUE expressed as a percent and defined as:

$$\mathrm{AFUE}=\frac{2{,}950\,\eta_{SS}\,\eta_u\,Q_{in-max}}{2{,}950\,\eta_{SS}\,Q_{in-max}+2.083(4{,}600)\,\eta_u\,Q_P}$$

where:

2,950=average number of heating degree days
η_{SS}=as defined as η_{SS-WT} in 4.2.4 of this appendix
η_u=as defined in 4.2.5 of this appendix
Q_{in-max}=as defined as Q_{in} at the maximum fuel input rate, as defined in 3.1 of this appendix
4,600=average number of non-heating season hours per year
Q_P=as defined in 3.5 of this appendix
2.083=(65–15)/24=50/24
65=degree day base temperature, °F
15=national average outdoor design temperature for vented heaters as defined in section 4.1.10 of this appendix
24=number of hours in a day

4.2.6.2 For manually controlled vented heaters where the pilot light can be turned off by the user when the heater is not in use as described in section 3.5.2, calculate the AFUE expressed as a percent and defined as:

AFUE=η_u

where:

η_u=as defined in section 4.2.5 of this appendix

4.3 *Annual fuel utilization efficiency by the tracer gas method.* The annual fuel utilization efficiency shall be determined by the following tracer gas method for all vented heaters equipped with thermal stack dampers. All other types of vented heaters can elect to use the following tracer gas method, as an optional procedure.

4.3.1 *On-cycle sensible heat loss.* For vented heaters equipped with single stage thermostats, calculate the on-cycle sensible heat loss ($L_{S,ON}$) expressed as a percent and defined as:

$L_{S,ON}=L_{S,SS,A}$

where:

$L_{S,SS,A}$=as defined in 4.1.9 of this appendix

For vented heaters equipped with two stage thermostats, calculate $L_{S,ON}$ defined as:

$L_{S,ON}=X_1\,L_{S,SS,A\text{-}red}+X_2\,L_{S,SS,A\text{-}max}$

where:

X_1=as defined in 4.1.14 of this appendix
$L_{S,SS,A\text{-}red}$=as defined as $L_{S,SS,A}$ in 4.1.9 of this appendix at the reduced fuel input rate
X_2=as defined in 4.1.15 of this appendix

$L_{S,SS,A\text{-}max}$=as defined as $L_{S,SS,A}$ in 4.1.9 of this appendix at the maximum fuel input rate

For vented heaters with step-modulating thermostats, calculate $L_{S,ON}$ defined as:

$L_{S,ON}=X_1\ L_{S,SS,A\text{-}red}+X_2\ L_{S,SS,A\text{-}avg}$

where:

X=$_1$-as defined in 4.1.14 of this appendix
$L_{LS,SS,A\text{-}red}$=as defined in 4.3.1 of this appendix
X_2=as defined in 4.1.15 of this appendix
$L_{S,SS,A\text{-}avg}$=average sensible heat loss for step-modulating vented heaters operating in the modulating mode

$$L_{S,SS,A-avg}=\left[\left[L_{S,SS,A-max}-L_{S,SS,A-red}\right]\left[\frac{T_C-T_{OA*}}{TC-15}\right]\right]+L_{S,SS,A-red}$$

where:

$L_{S,SS,A\text{-}avg}$=as defined in 4.3.1 of this appendix
T_C=as defined in 4.1.10 of this appendix
T_{OA*}=as defined in 4.1.10 of this appendix
15=as defined in 4.1.10 of this appendix

4.3.2 *On-cycle infiltration heat loss.* For vented heaters equipped with single stage thermostats, calculate the on-cycle infiltration heat loss ($L_{I,ON}$) expressed as a percent and defined as:

$L_{I,ON}=K_{I,ON}(70\text{–}45)$

where:

$K_{I,ON}$=as defined in 4.2.2 of this appendix
70=as defined in 4.2.3 of this appendix
45=as defined in 4.2.3 of this appendix

For vented heaters equipped with two stage thermostats, calculate $L_{I,ON}$ defined as:

$L_{I,ON}=X_1K_{I,ON\text{-}Max}(70\text{–}T_{OA*})+X_2K_{I,ON,red}(70\text{–}T_{OA})$

where:

X_1=as defined in 4.1.14 of this appendix
$K_{I,\ ON\text{-}max}$=as defined as $K_{I,ON}$ in 4.2.2 of this appendix at the maximum heat input rate
70=as defined in 4.2.3 of this appendix
T_{OA*}=as defined in 4.3.4 of this appendix
$K_{I,ON,red}$=as defined as $K_{I,ON}$ in 4.2.2 of this appendix at the minimum heat input rate
T_{OA}=as defined in 4.3.4 of this appendix
X_2=as defined in 4.1.15 of this appendix

For vented heaters equipped with step-modulating thermostats, calculate $L_{I,ON}$ defined as:

$L_{I,ON}=X_1\ K_{I,ON\text{-}avg}(70\text{–}T_{OA*})+X_2\ K_{I,ON\text{-}red}(70\text{–}T_{OA})$

where:

X_1=as defined in 4.1.14 of this appendix

$$K_{I,on,avg}=\frac{\left[K_{I,on,max}+K_{I,ON,red}\right]}{2}$$

70=as defined in 4.2.3 of this appendix
T_{OA*}=as defined in 4.3.4 of this appendix
X_2=as defined in 4.1.15 of this appendix
T_{OA}=as defined in 4.3.4 of this appendix

4.3.3 *Off-cycle sensible heat loss.* For vented heaters equipped with single stage thermostats, calculate the off-cycle sensible heat loss ($L_{S,OFF}$) at the maximum fuel input rate. For vented heaters equipped with step-modulating thermostats, calculate $L_{S,OFF}$ defined as:

$L_{S,OFF}=X_1\ L_{S,OFF,red}$

where:

X_1=as defined in 4.1.14 of this appendix
$L_{S,OFF,red}$=as defined as $L_{S,OFF}$ in 4.3.3 of this appendix at the reduced fuel input rate

For vented heaters equipped with two stage thermostats, calculate $L_{S,OFF}$ defined as:

$L_{S,OFF}=X_1\ L_{S,OFF,red}+X_2\ L_{S,OFF,Max}$

where:

X_1=as defined in 4.1.14 of this appendix
$L_{S,OFF,red}$=as defined as $L_{S,OFF}$ in 4.3.3 of this appendix at the reduced fuel input rate
X_2=as defined in 4.1.15 of this appendix
$L_{S,OFF,Max}$=as defined as $L_{S,OFF}$ in 4.3.3 of this appendix at the maximum fuel input rate

Calculate the off-cycle sensible heat loss ($L_{S,OFF}$) expressed as a percent and defined as:

$$L_{S,OFF} = \frac{100(0.24)}{.Q_{in} t_{on}} \sum m_{S,OFF} \left(T_{S,OFF} - T_{RA}\right)$$

where:

100=conversion factor for percent

0.24=specific heat of air in Btu per pound−°F

Q_{in}=fuel input rate, as defined in 3.1 of this appendix in Btu per minute (as appropriate for the firing rate)

t_{on}=average burner on-time per cycle and is 20 minutes

$\Sigma\ m_{S,OFF}(T_{S,OFF} - T_{RA})$=summation of the twenty values of the quantity, $m_{S,OFF}(T_{S,OFF} - T_{RA})$, measured in accordance with 3.3 of this appendix

$m_{S,OFF}$=stack gas mass flow rate pounds per minute

$$m_{S,OFF} = \frac{1.325 P_B V_T \left(100 - C_T\right)}{C_T \left(T_T + 460\right)}$$

$T_{S,OFF}$=stack gas temperature measured in accordance with 3.3 of this appendix

T_{RA}=average room temperature measured in accordance with 3.3 of this appendix

P_B=barometric pressure in inches of mercury

V_T=flow rate of the tracer gas through the stack in cubic feet per minute

C_{T*}=concentration by volume of the active tracer gas in the mixture in percent and is 100 when the tracer gas is a single component gas

C_T=concentration by volume of the active tracer gas in the diluted stack gas in percent

T_T=temperature of the tracer gas entering the flow meter in degrees Fahrenheit

(T_T+460)=absolute temperature of the tracer gas entering the flow meter in degrees Rankine

4.3.4 *Average outdoor temperature.* For vented heaters equipped with single stage thermostats, the average outdoor temperature (T_{OA}) is 45 °F. For vented heaters equipped with either two stage thermostats or step-modulating thermostats, T_{OA} during the reduced operating mode is obtained from Table 3 or Figure 1 of this appendix. For vented heaters equipped with two stage thermostats, T_{OA}* during the maximum operating mode is obtained from Table 3 or Figure 1 of this appendix.

4.3.5 *Off-cycle infiltration heat loss.* For vented heaters equipped with single stage thermostats, calculate the off-cycle infiltration heat loss ($L_{I,OFF}$) at the maximum fuel input rate. For vented heaters equipped with step-modulating thermostats, calculate $L_{I,OFF}$ defined as:

$L_{I,OFF}=X_1\ L_{I,OFF,red}$

where:

X_1=as defined in 4.1.14 of this appendix

$L_{I,OFF,red}$=as defined in $L_{I,OFF}$ in 4.3.3 of this appendix at the reduced fuel input rate

For vented heaters equipped with two stage thermostats, calculate $L_{I,OFF}$ defined as:

$L_{I,OFF}=X_1\ L_{I,OFF,red}+ X_2\ L_{I,OFF,max}$

where:

X_1=as defined in 4.1.14 of this appendix

$L_{I,OFF,red}$=as defined as $L_{I,OFF}$ in 4.3.3 of this appendix at the reduced fuel input rate

X_2=as defined in 4.1.15 of this appendix

$L_{I,OFF,Max}$=as defined as $L_{I,OFF}$ in 4.3.3 of this appendix at the maximum fuel input rate

Calculate the off-cycle infiltration heat loss ($L_{I,OFF}$) expressed as a percent and defined as:

$$L_{I,OFF} = \frac{100(0.24)(1.3)(0.7)\left(70 - T_{OA}\right)}{Q_{in} t_{on}} \sum m_{S,OFF}$$

where:

100=conversion factor for percent

0.24=specific heat of air in Btu per pound−°F

1.3=dimensionless factor for converting laboratory measured stack flow to typical field conditions

0.7=infiltration parameter

70=assumed average indoor air temperature, °F

T_{OA}=average outdoor temperature as defined in 4.3.4 of this appendix

Q_{in}=fuel input rate, as defined in 3.1 of this appendix in Btu per minute (as appropriate for the firing rate)

t_{on}=average burner on-time per cycle and is 20 minutes

$\Sigma\ m_{S,OFF}$=summation of the twenty values of the quantity, $m_{S,OFF}$, measured in accordance with 3.3 of this appendix

$m_{S,OFF}$=as defined in 4.3.3 of this appendix

4.3.6 *Part-load fuel utilization efficiency*. Calculate the part-load fuel utilization efficiency (η_u) expressed as a percent and defined as:

$$\eta_u = 100 - L_{L,A} - C_j L_j \left[\frac{t_{on}}{t_{on} + P_F t_{off}} \right] + \left[L_{s,on} + L_{s,OFF} + L_{I,on} + L_{s,OFF} \right]$$

where:
C_j=2.8, adjustment factor
L_j=jacket loss as defined in 4.1.5
$L_{L,A}$=as defined in 4.1.6 of this appendix
t_{on}=as defined in 4.3.3 of this appendix
$L_{S,ON}$=as defined in 4.3.1 of this appendix
$L_{S,OFF}$=as defined in 4.3.3 of this appendix
$L_{I,ON}$=as defined in 4.3.2 of this appendix
$L_{I,OFF}$=as defined in 4.1.4 of this appendix
P_F=as defined in 4.1.4 of this appendix
t_{OFF}=average burner off-time per cycle and is 20 minutes

4.3.7 Annual Fuel Utilization Efficiency. Calculate the AFUE expressed as a percent and defined as:

$$AFUE = \frac{2{,}950\ \eta_{SS-WT}\ \eta_u\ Q_{in-max}}{2{,}950\ \eta_{SS-WT}\ Q_{in-max} + 2.083(4{,}600)\eta_u\ Q_P}$$

where:
2,950=average number of heating degree days
η_{SS-WT}=as defined in 4.1.16 of this appendix
η_u=as defined in 4.3.6 of this appendix
Q_{in-max}=as defined in 4.2.6 of this appendix
4,600=as specified in 4.2.6 of this appendix
Q_P=as defined in 3.5 of this appendix
2.083=as specified in 4.2.6 of this appendix

4.4 *Stack damper effectiveness for vented heaters equipped with electro-mechanical stack dampers*. Determine the stack damper effectiveness for vented heaters equipped with electro-mechanical stack dampers (D_o), defined as:

D_o=1.62 [1—A_D cos Ω/A_S]

where:
A_D=as defined in 3.4 of this appendix
Ω=as defined in 3.4 of this appendix
A_S=as defined in 3.4 of this appendix

4.5 *Addition requirements for vented home heating equipment using indoor air for combustion and draft control*. For vented home heating equipment using indoor air for combustion and draft control, D_F, as described in section 4.1.2 of this appendix, and D_S, as described in section 4.1.3 of this appendix, shall be determined from Table 1 of this appendix.

4.5.1 *Optional procedure for determining* D_P *for vented home heating equipment*. Calculate the ratio (D_P) of the rate of flue gas mass through the vented heater during the off-period, $M_{F,OFF}(T_{F,SS})$, to the rate of flue gas mass flow during the on-period, $M_{F,SS}(T_{F,SS})$, and defined as:

$D_P=M_{F,OFF}(T_{F,SS})/M_{F,SS}(T_{F,SS})$

For vented heaters in which no draft is maintained during the steady-state or cool down tests, $M_{F,OFF}(T_{F,SS})$ is defined as:

$$M_{F,OFF}\left(T_{F,SS}\right) = M_{F,OFF}\left(T^*_{F,OFF}\right)\left[\frac{T_{F,SS} - T_{RA}}{T^*_{F,OFF} - T_{RA}}\right]^{0.56}\left[\frac{T^*_{F,OFF} + 460}{T_{F,SS} + 460}\right]^{1.19}$$

For oil fueled vented heaters in which an imposed draft is maintained, as described in section 3.6 of this appendix, $M_{F,OFF}(T_{F,SS})$ is defined as:

$M_{F,OFF}(T_{F,SS})=M_{F,OFF}(T^*_{F,SS})$

where:
$T_{F,SS}$=as defined in 3.1.1 of this appendix
$T^*_{F,OFF}$=flue gas temperature during the off-period measured in accordance with 3.6 of this appendix in degrees Fahrenheit
T_{RA}=as defined in 2.9 of this appendix

$$M_{F,OFF}\left(T_{F,OFF}\right)=\frac{1.325P_BV_T\left(100-C_T\right)}{C_T\left(T_T+460\right)}$$

p_B=barometric pressure measured in accordance with 3.6 of this appendix in inches of mercury
V_T=flow rate of tracer gas through the vented heater measured in accordance with 3.6 of this appendix in cubic feet per minute
C_T=concentration by volume of tracer gas present in the flue gas sample measured in accordance with 3.6 of this appendix in percent
C_T*=concentration by volume of the active tracer gas in the mixture in percent and is 100 when the tracer gas is a single component gas
T_T=the temperature of the tracer gas entering the flow meter measured in accordance with 3.6 of this appendix in degrees Fahrenheit
(T_T+460)=absolute temperature of the tracer gas entering the flow meter in degrees Rankine
$M_{F,SS}(T_{F,SS})=Q_{in}[R_{T,F}(A/F)+1]/[60HHV_A]$
Q_{in}=as defined in 3.1 of this appendix
$R_{T,F}$=as defined in 4.1.7 of this appendix
A/F=as defined in 4.2.2 of this appendix
HHV_A=as defined in 4.2.2 of this appendix

4.5.2 *Optional procedure for determining off-cycle draft factor for flue gas flow for vented heaters.* For systems numbered 1 thru 10, calculate the off-cycle draft factor for flue gas flow (D_F) defined as:

$D_F=D_P$

For systems numbered 11 or 12: $D_F=D_P\ D_O$

where:

D_p=as defined in 4.5.1. of this appendix
D_O=as defined in 4.4 of this appendix

4.5.3 *Optional procedure for determining off-cycle draft factor for stack gas flow for vented heaters.* Calculate the off-cycle draft factor for stack gas flow (D_S) defined as:

For systems numbered 1 or 2: D_S=1.0
For systems numbered 3 or 4: $D_S=(D_P+0.79)/1.4$
For systems numbered 5 or 6: $D_S=D_O$
For systems numbered 7 or 8 and if $D_O(S/F)<1$:$D_S=D_O\ D_P$
For systems numbered 7 or 8 and if $D_O(S/F)>1$:

$D_S=D_O\ D_P+[0.85-D_O\ D_P]\ [D_O(S/F)-1]/[S/F-1]$

where:

D_P=as defined in 4.5.1 of this appendix
D_O=as defined in 4.4 of this appendix

4.6 *Annual energy consumption.*

4.6.1 *National average number of burner operating hours.* For vented heaters equipped with single stage controls or manual controls, the national average number of burner operating hours (BOH) is defined as:

$BOH_{SS}=1{,}416A_FA\ DHR-1{,}416\ B$

where:

1,416=national average heating load hours for vented heaters based on 2,950 degree days and 15 °F outdoor design temperature
A_F=0.7067, adjustment factor to adjust the calculated design heating requirement and heating load hours to the actual heating load experienced by the heating system
DHR=typical design heating requirements based on Q_{OUT}, from Table 4 of this appendix.
$Q_{OUT}=[(\eta_{SS}/100)-C_j\ (L_j/100)]\ Q_{in}$
L_j=jacket loss as defined in 4.1.5 of this appendix
C_j=2.8, adjustment factor as defined in 4.3.6 of this appendix
η_{SS}=steady-state efficiency as defined in 4.1.10 of this appendix, percent
Q_{in}=as defined in 3.1 of this appendix at the maximum fuel input rate
$A=100{,}000/[341{,}300P_E+(Q_{in}-Q_P)\eta_u]$
$B=2.938(Q_P)\ \eta_u\ A/100{,}000$
100,000=factor that accounts for percent and kBtu
P_E=as defined in 3.1.3 of this appendix
Q_P=as defined in 3.5 of this appendix
η_u=as defined in 4.3.6 of this appendix for vented heaters using the tracer gas method, percent
=as defined in 4.2.5 of this appendix for manually controlled vented heaters, percent
$=2{,}950\ AFUE\eta_{SS}\ Q_{in}/[2{,}950\ \eta_{SS}\ Q_{in}$—$AFUE(2.083)(4{,}600)Q_P]$, for vented heaters equipped without manual controls and without thermal stack dampers and not using the optional tracer gas method, where:
AFUE=as defined in 4.1.17 of this appendix, percent
2,950=average number of heating degree days as defined in 4.2.6 of this appendix
4,600=average number of non-heating season hours per year as defined in 4.2.6 of this appendix
2.938=(4,160/1,416)=ratio of the average length of the heating season in hours to the average heating load hours
2.083=as specified in 4.2.6 of this appendix

4.6.1.1 For vented heaters equipped with two stage or step modulating controls the national average number of burner operating hours at the reduced operating mode is defined as:

$BOH_R=X_1E_M/Q_{red\text{-}in}$

where:

X_1=as defined in 4.1.14 of this appendix
$Q_{red\text{-}in}$=as defined in 4.1.11 of this appendix
E_M=average annual energy used during the heating season
$=(Q_{in}-Q_P)BOH_{SS}+(8{,}760-4{,}600)Q_P$
Q_{in}=as defined in 3.1 of this appendix at the maximum fuel input rate

Q_P=as defined in 3.5 of this appendix
BOH_{SS}=as defined in 4.6.1 of this appendix, in which the term P_E in the factor A is increased by the factor R, which is defined in 3.1.3 of this appendix as:
R=1.3 for two stage controls
=1.4 for step modulating controls when the ratio of minimum-to-maximum fuel input is greater than or equal to 0.7
=1.7 for step modulating controls when the ratio of minimum-to-maximum fuel input is less than 0.7 and greater than or equal to 0.5
=2.2 for step modulating controls when the ratio of minimum-to-maximum fuel input is less than 0.5
$A=100{,}000/[341{,}300\ PE\ R+(Q_{in}-Q_P)\eta_u]$
8,760=total number of hours per year
4,600=as specified in 4.2.6 of this appendix

4.6.1.2 For vented heaters equipped with two stage or step modulating controls the national average number of burner operating hours at the maximum operating mode (BOH_H) is defined as:

$$BOH_H=X_2E_M/Q_{in}$$

where:

X_2=as defined in 4.1.15 of this appendix
E_M=average annual energy used during the heating season
$=(Q_{in}-Q_P)BOH_{SS}+(8{,}760-4{,}600)Q_P$
Q_{in}=as defined in 3.1 of this appendix at the maximum fuel input rate

4.6.2 *Average annual fuel energy for gas or oil fueled vented heaters.* For vented heaters equipped with single stage controls or manual controls, the average annual fuel energy consumption (E_F) is expressed in Btu per year and defined as:

$$E_F=BOH_{SS}\ (Q_{in}-Q_P)+8{,}760\ Q_P$$

where:

BOH_{SS}=as defined in 4.6.1 of this appendix
Q_{in}=as defined in 3.1 of this appendix
Q_P=as defined in 3.5 of this appendix
8,760=as specified in 4.6.1 of this appendix

4.6.2.1 For vented heaters equipped with either two stage or step modulating controls E_F is defined as:

$$E_F=E_M+4{,}600Q_P$$

where:

E_M=as defined in 4.6.1.2 of this appendix
4,600=as specified 4.2.6 of this appendix
Q_P=as defined in 3.5 of this appendix

4.6.3 *Average annual auxiliary electrical energy consumption for vented heaters.* For vented heaters with single stage controls or manual controls the average annual auxiliary electrical consumption (E_{AE}) is expressed in kilowatt-hours and defined as:

$$E_{AE}=BOH_{SS}P_E$$

where:

BOH_{SS}=as defined in 4.6.1 of this appendix
P_E=as defined in 3.1.3 of this appendix

4.6.3.1 For vented heaters equipped with two stage or modulating controls E_{AE} is defined as:

$$E_{AE}=(BOH_R+BOH_H)P_E$$

where:

BOH_R=as defined in 4.6.1 of this appendix
BOH_H=as defined in 4.6.1 of this appendix
P_E=as defined in 3.1.3 of this appendix

4.6.4 *Average annual energy consumption for vented heaters located in a different geographic region of the United States and in buildings with different design heating requirements.*

4.6.4.1 *Average annual fuel energy consumption for gas or oil fueled vented home heaters located in a different geographic region of the United States and in buildings with different design heating requirements.* For gas or oil fueled vented heaters the average annual fuel energy consumption for a specific geographic region and a specific typical design heating requirement (E_{FR}) is expressed in Btu per year and defined as:

$$E_{FR}=(E_F-8{,}760\ Q_P)(HLH/1{,}416)+8{,}760Q_P$$

where:

E_F=as defined in 4.6.2 of this appendix
8,760=as specified in 4.6.1 of this appendix
Q_P=as defined in 3.5 of this appendix
HLH=heating load hours for a specific geographic region determined from the heating load hour map in Figure 3 of this appendix
1,416=as specified in 4.6.1 of this appendix

4.6.4.2 *Average annual auxiliary electrical energy consumption for gas or oil fueled vented home heaters located in a different geographic region of the United States and in buildings with different design heating requirements.* For gas or oil fueled vented home heaters the average annual auxiliary electrical energy consumption for a specific geographic region and a specific typical design heating requirement (E_{AER}) is expressed in kilowatt-hours and defined as:

$$E_{AER}=E_{AE}\ HLH/1{,}416$$

where:

E_{AE}=as defined in 4.6.3 of this appendix
HLH=as defined in 4.6.4.1 of this appendix
1,416=as specified in 4.6.1 of this appendix

TABLE 1—OFF-CYCLE DRAFT FACTORS FOR FLUE GAS FLOW (D_F) AND FOR STACK GAS FLOW (D_S) FOR VENTED HOME HEATING EQUIPMENT EQUIPPED WITHOUT THERMAL STACK DAMPERS

System number	(D_F)	(D_S)	Burner type	Venting system type [1]
1	1.0	1.0	Atmospheric	Draft hood or diverter.
2	0.4	1.0	Power	Draft hood or diverter.
3	1.0	1.0	Atmospheric	Barometric draft regulator.
4	0.4	0.85	Power	Barometric draft regulator.
5	1.0	D_o	Atmospheric	Draft hood or diverter with damper.
6	0.4	D_o	Power	Draft hood or diverter with damper.
7	1.0	D_o	Atmospheric	Barometric draft regulator with damper.
8	0.4	D_o D_p	Power	Barometric draft regulator with damper.
9	1.0	....	Atmospheric	Direct vent.
10	0.4	....	Power	Direct vent.
11	D_o	....	Atmospheric	Direct vent with damper.
12	0.4 D_o	....	Power	Direct vent with damper.

[1] Venting systems listed with dampers means electro-mechanical dampers only.

TABLE 2—VALUES OF HIGHER HEATING VALUE ($HHV_{(A)}$), STOICHIOMETRIC AIR/FUEL (A/F), LATENT HEAT LOSS ($L_{L,A}$) AND FUEL-SPECIFIED PARAMETERS (A, B, C, AND D) FOR TYPICAL FUELS

Fuels	HHV_A (Btu/lb)	A/F	$L_{L,A}$	A	B	C	D
No. 1 oil	19,800	14.56	6.55	0.0679	14.22	0.0179	0.167
No. 2 oil	19,500	14.49	6.50	0.0667	14.34	0.0181	0.167
Natural gas	20,120	14.45	9.55	0.0919	10.96	0.0175	0.171
Manufactured gas	18,500	11.81	10.14	0.0965	10.10	0.0155	0.235
Propane	21,500	15.58	7.99	0.0841	12.60	0.0177	0.151
Butane	20,000	15.36	7.79	0.0808	12.93	0.0180	0.143

TABLE 3—FRACTION OF HEATING LOAD AT REDUCED OPERATING MODE (X1) AND AT MAXIMUM OPERATING MODE (X2), AVERAGE OUTDOOR TEMPERATURES (TOA AND TOA*), AND BALANCE POINT TEMPERATURE (TC) FOR VENTED HEATERS EQUIPPED WITH EITHER TWO-STAGE THERMOSTATS OR STEP-MODULATING THERMOSTATS

Heat output ratio [a]	X1	X2	TOA	TOA*	TC
0.20 to 0.24	.12	.88	57	40	53
0.25 to 0.29	.16	.84	56	39	51
0.30 to 0.34	.20	.80	54	38	49
0.35 to 0.39	.30	.70	53	36	46
0.40 to 0.44	.36	.64	52	35	44
0.45 to 0.49	.43	.57	51	34	42
0.50 to 0.54	.52	.48	50	32	39
0.55 to 0.59	.60	.40	49	30	37
0.60 to 0.64	.70	.30	48	29	34
0.65 to 0.69	.76	.24	47	27	32
0.70 to 0.74	.84	.16	46	25	29
0.75 to 0.79	.88	.12	46	22	27
0.80 to 0.84	.94	.06	45	20	23
0.85 to 0.89	.96	.04	45	18	21
0.90 to 0.94	.98	.02	44	16	19
0.95 to 0.99	.99	.01	44	13	17

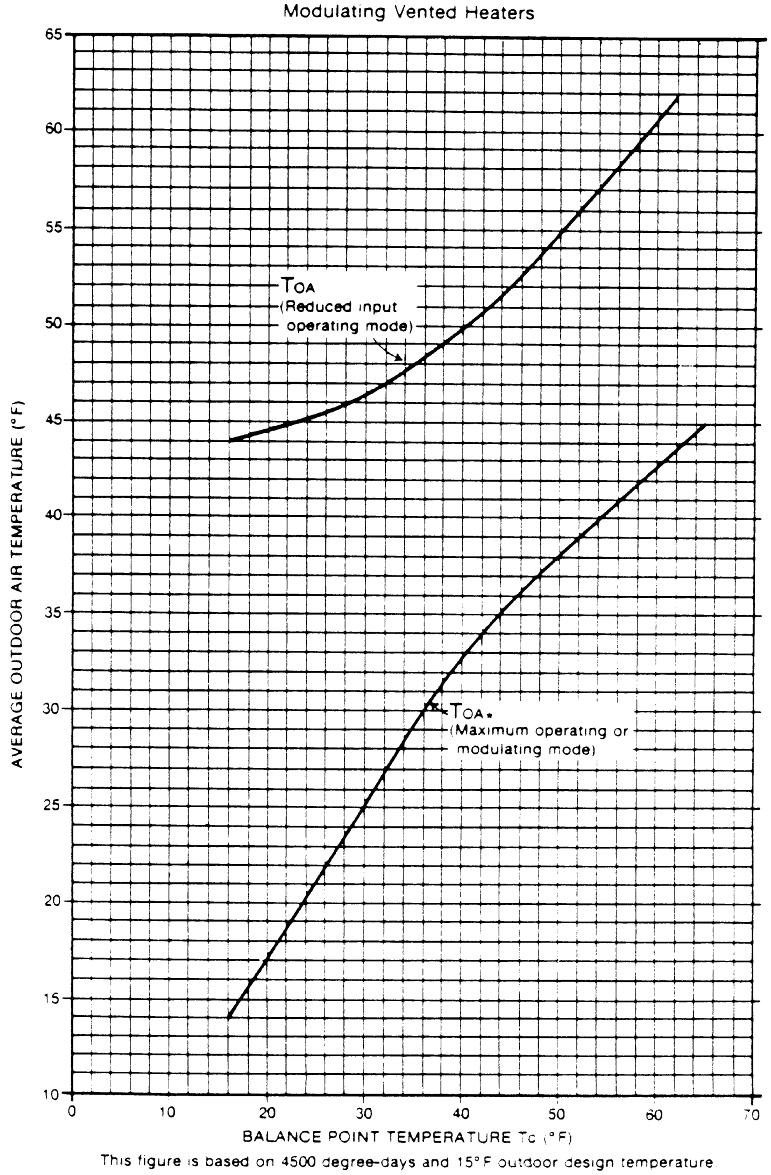
[a] The heat output ratio means the ratio of minimum to maximum heat output rates as defined in 4.1.13.

TABLE 4—AVERAGE DESIGN HEATING REQUIREMENTS FOR VENTED HEATERS WITH DIFFERENT OUTPUT CAPACITIES

Vented heaters output capacity Q_{out}—(Btu/hr)	Average design heating requirements (kBtu/hr)
5,000–7,499	5.0
7,500–10,499	7.5
10,500–13,499	10.0
13,500–16,499	12.5
16,500–19,499	15.0
19,500–22,499	17.5
22,500–26,499	20.5
26,500–30,499	23.5
30,500–34,499	26.5
34,500–38,499	30.0
38,500–42,499	33.5
42,500–46,499	36.5
46,500–51,499	40.0
51,500–56,499	44.0
56,500–61,499	48.0
61,500–66,499	52.0
66,500–71,499	56.0
71,500–76,500	60.0

FIGURE 1

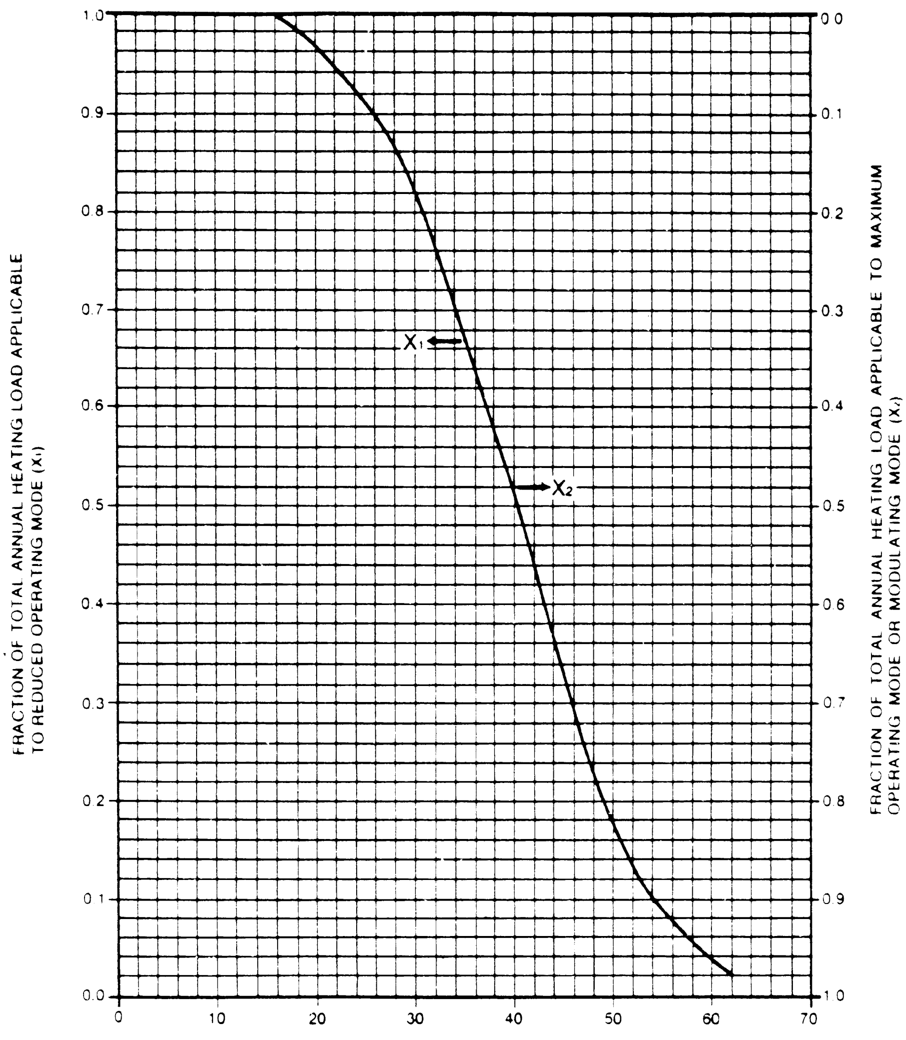
Average Outdoor Air Temperature vs. Balance Point Temperature for Modulating Vented Heaters



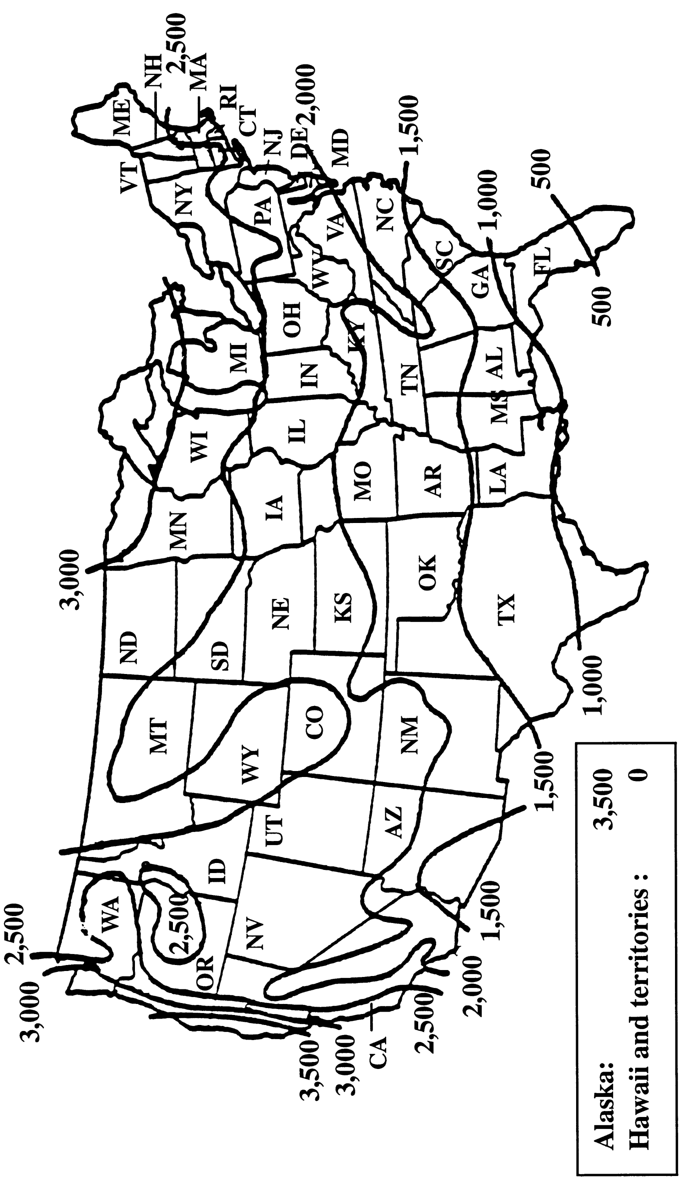
This figure is based on 4500 degree-days and 15°F outdoor design temperature

FIGURE 2

Fraction of Total Annual Heating Load Applicable to Reduced Operating Mode (X_1) and to Maximum Operating Mode or Modulating Mode (X_2) vs. Balance Point Temperature for Modulating Vented Heaters



This figure is based on 4500 degree-days and 15°F outdoor design temperature



This map is reasonably accurate for most parts of the United States but is necessarily generalized, and consequently not too accurate in mountainous regions, particularly in the rockies.

FIGURE 3- HEATING LOAD HOURS (HLH) FOR THE UNITED STATES

[49 FR 12169, Mar. 28, 1984, as amended at 62 FR 26162, May 12, 1997]

APPENDIX P TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF POOL HEATERS

1. Test method. The test method for testing pool heaters is as specified in American National Standards Institute Standard for Gas-Fired Pool Heaters, Z21.56–1994.

2. Test conditions. Establish the test conditions specified in section 2.9 of ANSI Z21.56–1994.

3. Measurements. Measure the quantities delineated in section 2.9 of ANSI Z21.56–1994. The measurement of energy consumption for oil-fired pool heaters in Btu is to be carried out in appropriate units, e.g., gallons.

4. Calculations

4.1 *Thermal efficiency.* Calculate the thermal efficiency, E_t (expressed as a percent), as specified in section 2.9 of ANSI Z21.56–1994. The expression of fuel consumption for oil-fired pool heaters shall be in Btu.

4.2 *Average annual fossil fuel energy for pool heaters.* The average annual fuel energy for pool heater, E_F, is defined as:

$$E_F = BOH\ Q_{IN} + (POH - BOH)Q_P$$

where:

BOH=average number of burner operating hours=104 h

POH=average number of pool operating hours=4464 h

Q_{IN}=rated fuel energy input as defined according to 2.9.1 or 2.9.2 of ANSI Z21.56–1994, as appropriate

Q_P=energy consumption of continuously operating pilot light if employed, in Btu/h.

4.3 *Average annual auxiliary electrical energy consumption for pool heaters.* The average annual auxiliary electrical energy consumption for pool heaters, E_{AE}, is expressed in Btu and defined as:

$$E_{AE} = BOH\ PE$$

where:

$PE = 2E_c$ if heater tested according to 2.9.1 of ANSI Z21.56–1994

$=3.412\ PE_{rated}$ if heater tested according to 2.9.2 of ANSI Z21.56–1994, in Btu/h

E_c=Electrical consumption of the heater (converted to equivalent unit of Btu), including the electrical energy to the recirculating pump if used, during the 30-minute thermal efficiency test, as defined in 2.9.1 of ANSI Z21.56–1994, in Btu per 30 min.

2=Conversion factor to convert unit from per 30 min. to per h.

PE_{rated}=nameplate rating of auxiliary electrical equipment of heater, in Watts

BOH=as defined in 4.2 of this appendix

4.4 *Heating seasonal efficiency.*

4.4.1 Calculate the seasonal useful output of the pool heater as:

$$E_{OUT} = BOH\ [(E_t/100)(Q_{IN} + PE)]$$

where:

BOH=as defined in 4.2 of this appendix

E_t=thermal efficiency as defined in 4.1 of this appendix

Q_{IN}=as defined in 4.2 of this appendix

PE=as defined in 4.3 of this appendix

100=conversion factor, from percent to fraction

4.4.2 Calculate the seasonal input to the pool heater as:

$$E_{IN} = BOH\ (Q_{IN} + PE) + (POH - BOH)\ Q_P$$

where:

BOH=as defined in 4.2 of this appendix

Q_{IN}=as defined in 4.2 of this appendix

PE=as defined in 4.3 of this appendix

POH=as defined in 4.2 of this appendix

Q_P=as defined in 4.2 of this appendix

4.4.3 *Calculate the pool heater heating seasonal efficiency (in percent).*

4.4.3.1 For pool heaters employing a continuous pilot light:

$$EFFY_{HS} = 100(E_{OUT}/E_{IN})$$

where:

E_{OUT}=as defined in 4.4.1 of this appendix

E_{IN}=as defined in 4.4.2 of this appendix

100=to convert a fraction to percent

4.4.3.2 For pool heaters without a continuous pilot light:

$$EFFY_{HS} = E_t$$

where:

E_t=as defined in 4.1 of this appendix.

[62 FR 26165, May 12, 1997]

APPENDIX Q TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FLUORESCENT LAMP BALLASTS

1. Definitions

1.1 *AC control signal* means an alternating current (AC) signal that is supplied to the ballast using additional wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.2 *ANSI Standard* means a standard developed by a committee accredited by the American National Standards Institute.

1.3 *Ballast input voltage* means the rated input voltage of a fluorescent lamp ballast.

1.4 *DC control signal* means a direct current (DC) signal that is supplied to the ballast using additional wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.5 *F4OT12 lamp* means a nominal 40 watt tubular fluorescent lamp which is 48 inches in length and one and a half inches in diameter, and conforms to ANSI C78.81–2003 (Data

Sheet 7881–ANSI–1010–1) (incorporated by reference; *see* § 430.3).

1.6 *F96T12 lamp* means a nominal 75 watt tubular fluorescent lamp which is 96 inches in length and one and one-half inches in diameter, and conforms to ANSI C78.81–2003 (Data Sheet 7881–ANSI–3007–1) (incorporated by reference; *see* § 430.3).

1.7 *F96T12HO lamp* means a nominal 110 watt tubular fluorescent lamp that is 96 inches in length and 1½ inches in diameter, and conforms to ANSI C78.81–2003 (Data Sheet 7881–ANSI–1019–1) (incorporated by reference; *see* § 430.3).

1.8 *F34T12 lamp* (also known as a "F40T12/ES lamp") means a nominal 34 watt tubular fluorescent lamp that is 48 inches in length and 1½ inches in diameter, and conforms to ANSI C78.81–2003 (Data Sheet 7881–ANSI–1006–1) (incorporated by reference; *see* § 430.3).

1.9 *F96T12/ES lamp* means a nominal 60 watt tubular fluorescent lamp that is 96 inches in length and 1½ inches in diameter, and conforms to ANSI C78.81–2003 (Data Sheet 7881–ANSI–3006–1) (incorporated by reference; *see* § 430.3).

1.10 *F96T12HO/ES lamp* means a nominal 95 watt tubular fluorescent lamp that is 96 inches in length and 1½ inches in diameter, and conforms to ANSI C78.81–2003 (Data Sheet 7881–ANSI–1017–1) (incorporated by reference; *see* § 430.3).

1.11 *Input current* means the root-mean-square (RMS) current in amperes delivered to a fluorescent lamp ballast.

1.12 *Luminaire* means a complete lighting unit consisting of a fluorescent lamp or lamps, together with parts designed to distribute the light, to position and protect such lamps, and to connect such lamps to the power supply through the ballast.

1.13 *Nominal lamp watts* means the wattage at which a fluorescent lamp is designed to operate.

1.14 *PLC control signal* means a power line carrier (PLC) signal that is supplied to the ballast using the input ballast wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.15 *Power Factor* means the power input divided by the product of ballast input voltage and input current of a fluorescent lamp ballast, as measured under test conditions specified in ANSI C82.2 (incorporated by reference; see § 430.3).

1.16 *Power input* means the power consumption in watts of a ballast a fluorescent lamp or lamps, as determined in accordance with the test procedures specified in ANSI C82.2 (incorporated by reference; see § 430.3).

1.17 *Relative light output* means the light output delivered through the use of a ballast divided by the light output of a reference ballast, expressed as a percent, as determined in accordance with the test procedures specified in ANSI C82.2 (incorporated by reference; see § 430.3).

1.18 *Residential building* means a structure or portion of a structure which provides facilities or shelter for human residency, except that such term does not include any multifamily residential structure of more than three stores above grade.

1.19 *Standby mode* means the condition in which an energy-using product—

(a) Is connected to a main power source; and

(b) Offers one or more of the following user-oriented or protective functions:

(i) To facilitate the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer.

(ii) Continuous functions, including information or status displays (including clocks) or sensor-based functions.

1.20 *Wireless control signal* means a wireless signal that is radiated to and received by the ballast for the purpose of controlling the ballast and putting the ballast in standby mode.

2. *Test Conditions.*

2.1 *Measurement of Active Mode Energy Consumption, BEF.* The test conditions for testing fluorescent lamp ballasts shall be done in accordance with ANSI C82.2 (incorporated by reference; see § 430.3). Any subsequent amendment to this standard by the standard setting organization will not affect the DOE test procedures unless and until amended by DOE. The test conditions for measuring active mode energy consumption are described in sections 4, 5, and 6 of ANSI C82.2. The test conditions described in this section (2.1) are applicable to section 3.1 of section 3, Test Method and Measurements. For section 2.1 and 3, when ANSI C82.2 is referenced, ANSI C78.81–2010 (incorporated by reference; see § 430.3), ANSI C82.1 (incorporated by reference; see § 430.3), ANSI C82.11 (incorporated by reference; see § 430.3), and ANSI C82.13 (incorporated by reference; see § 430.3) shall be used instead of the versions listed as normative references in ANSI C82.2.

2.2 *Measurement of Standby Mode Power.* The measurement of standby mode power need not be performed to determine compliance with energy conservation standards for fluorescent lamp ballasts at this time. This and the previous statement will be removed as part of a rulemaking to amend the energy conservation standards for fluorescent lamp ballasts to account for standby mode energy consumption, and the following shall apply on the compliance date for any such requirements.

The test conditions for testing fluorescent lamp ballasts shall be done in accordance with ANSI C82.2 (incorporated by reference; see § 430.3). Any subsequent amendment to this standard by the standard setting organization will not affect the DOE test procedures unless and until amended by DOE. The test conditions for measuring standby power are described in sections 5, 7, and 8 of ANSI C82.2. Fluorescent lamp ballasts that are capable of connections to control devices shall be tested with all commercially available compatible control devices connected in all possible configurations. For each configuration, a separate measurement of standby power shall be made in accordance with section 3.2 of the test procedure.

3. TEST METHOD AND MEASUREMENTS

3.1 Active Mode Energy Efficiency Measurement

3.1.1 The test method for testing the active mode energy efficiency of fluorescent lamp ballasts shall be done in accordance with ANSI C82.2 (incorporated by reference; see §430.3). Where ANSI C82.2 references ANSI C82.1–1997, the operator shall use ANSI C82.1 (incorporated by reference; see §430.3) for testing low-frequency ballasts and ANSI C82.11 (incorporated by reference; see §430.3) for high-frequency ballasts.

3.1.2 *Instrumentation.* The instrumentation shall be as specified by sections 5, 7, 8, and 15 of ANSI C82.2 (incorporated by reference; see §430.3).

3.1.3 *Electric Supply.*

3.1.3.1 *Input Power.* Measure the input power (watts) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see §430.3), section 4.

3.1.3.2 *Input Voltage.* Measure the input voltage (volts) (RMS) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see §430.3), section 3.2.1 and section 4.

3.1.3.3 *Input Current.* Measure the input current (amps) (RMS) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see §430.3), section 3.2.1 and section 4.

3.1.4 *Light Output.*

3.1.4.1 Measure the light output of the reference lamp with the reference ballast in accordance with ANSI C82.2 (incorporated by reference; see §430.3), section 12.

3.1.4.2 Measure the light output of the reference lamp with the test ballast in accordance with ANSI C82.2 (incorporated by reference; see §430.3), section 12.

3.2 Standby Mode Power Measurement

3.2.1 The test for measuring standby mode energy consumption of fluorescent lamp ballasts shall be done in accordance with ANSI C82.2 (incorporated by reference; see §430.3).

3.2.2. Send a signal to the ballast instructing it to have zero light output using the appropriate ballast communication protocol or system for the ballast being tested.

3.2.3 *Input Power.* Measure the input power (watts) to the ballast in accordance with ANSI C82.2–2002, section 13, (incorporated by reference; *see* §430.3).

3.2.4 *Control Signal Power.* The power from the control signal path will be measured using all applicable methods described below.

3.2.4.1 *AC Control Signal.* Measure the AC control signal power (watts), using a wattmeter (W), connected to the ballast in accordance with the circuit shown in Figure 1.

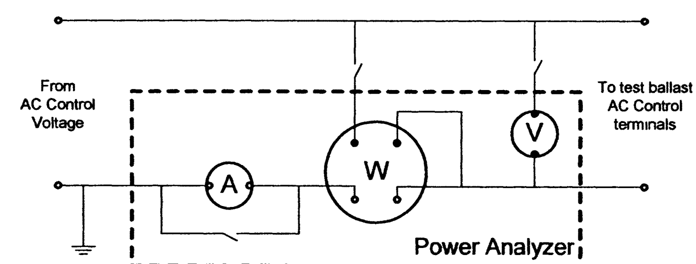


Figure 1: Circuit for Measuring AC Control Signal Power in Standby Mode

3.2.4.2 *DC Control Signal.* Measure the DC control signal voltage, using a voltmeter (V), and current, using an ammeter (A), connected to the ballast in accordance with the circuit shown in Figure 2. The DC control signal power is calculated by multiplying the DC control signal voltage and the DC control signal current.

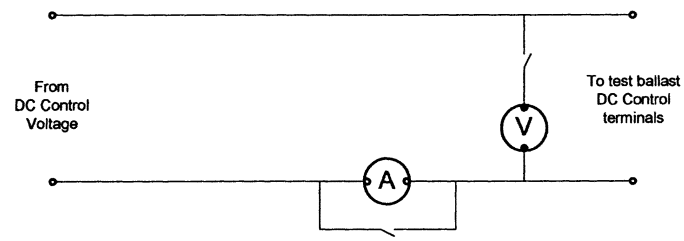


Figure 2: Circuit for Measuring DC Control Signal Power in Standby Mode

3.2.4.3 *Power Line Carrier (PLC) Control Signal.* Measure the PLC control signal power (watts), using a wattmeter (W), connected to the ballast in accordance with the circuit shown in Figure 3. The wattmeter must have a frequency response that is at least 10 times higher than the PLC being measured in order to measure the PLC signal correctly. The wattmeter must also be high-pass filtered to filter out power at 60 Hertz.

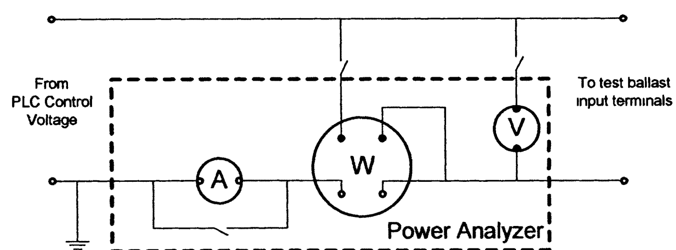


Figure 3: Circuit for Measuring PLC Control Signal Power in Standby Mode

3.2.4.4 *Wireless Control Signal.* The power supplied to a ballast using a wireless signal is not easily measured, but is estimated to be well below 1.0 watt. Therefore, the wireless control signal power is not measured as part of this test procedure.

4. *Calculations.*

4.1 Calculate relative light output:

$$\text{relative light output} = \frac{\text{Photocell output of lamp on test ballast}}{\text{Photocell output of lamp on reference ballast}} \times 100$$

Where: photocell output of lamp on test ballast is determined in accordance with section 3.1.4.2, expressed in watts, and photocell output of lamp on ref. ballast is determined in accordance with section 3.1.4.1, expressed in watts.

4.2. Determine the Ballast Efficacy Factor (BEF) using the following equations:

(a) Single lamp ballast

$$BEF = \frac{\text{relative light output}}{\text{input power}}$$

(b) Multiple lamp ballast

$$BEF = \frac{\text{average relative light output}}{\text{input power}}$$

Where:

Input power is determined in accordance with section 3.1.3.1, relative light output as defined in section 4.1, and average relative light output is the relative light output, as defined in section 4.1, for all lamps, divided by the total number of lamps.

4.3 Determine Ballast Power Factor (PF):

$$PF = \frac{\textit{Input power}}{\text{Input voltage} \times \text{input current}}$$

Where:

Input power is as defined in section 3.1.3.1, Input voltage is determined in accordance with section 3.1.3.2, expressed in volts, and Input current is determined in accordance with section 3.1.3.3, expressed in amps.

[54 FR 6076, Feb. 7, 1989, as amended at 56 FR 18682, April 24, 1991; 69 FR 18803, Apr. 9, 2004; 70 FR 60412, Oct. 18, 2005; 74 FR 54455, Oct. 22, 2009; 76 FR 25223, May 4, 2011]

EFFECTIVE DATE NOTE: At 76 FR 70628, Nov. 14, 2011, appendix Q to subpart B of part 430 was amended by adding introductory text after the heading, effective Jan. 13, 2012. For the convenience of the user, the added text is set forth as follows:

APPENDIX Q TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FLUORESCENT LAMP BALLASTS

Comply with appendix Q until November 14, 2014. After this date, all fluorescent lamp ballasts shall be tested using the provisions of appendix Q1.

* * * * *

APPENDIX Q1 TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FLUORESCENT LAMP BALLASTS

1. DEFINITIONS

1.1. *AC control signal* means an alternating current (AC) signal that is supplied to the ballast using additional wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.2. *Active Mode* means the condition in which an energy-using product—

(a) Is connected to a main power source;

(b) Has been activated; and

(c) Provides 1 or more main functions.

1.3. *Cathode heating* refers to power delivered to the lamp by the ballast for the purpose of raising the temperature of the lamp electrode or filament.

1.4. *Commercial ballast* is a fluorescent lamp ballast that is not a residential ballast as defined in section 1.13 and meets technical standards for non-consumer radio frequency lighting devices as specified in subpart C of 47 CFR part 18.

1.5. *DC control signal* means a direct current (DC) signal that is supplied to the ballast using additional wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.6. *High-frequency ballast* is as defined in ANSI C82.13 (incorporated by reference; see §430.3).

1.7. *Instant-start* is the starting method used instant-start systems as defined in ANSI C82.13 (incorporated by reference; see §430.3).

1.8. *Low-frequency ballast* is a fluorescent lamp ballast that operates at a supply frequency of 50 to 60 Hz and operates the lamp at the same frequency as the supply.

1.9. *PLC control signal* means a power line carrier (PLC) signal that is supplied to the ballast using the input ballast wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.10. *Programmed-start* is the starting method used in programmed-start systems as defined in ANSI C82.13 (incorporated by reference; see §430.3).

1.11. *Rapid-start* is the starting method used in rapid-start type systems as defined in ANSI C82.13 (incorporated by reference; see § 430.3).

1.12. *Reference lamp* is a fluorescent lamp that meets certain operating conditions as defined by ANSI C82.13 (incorporated by reference; see § 430.3).

1.13. *Residential ballast* is a fluorescent lamp ballast designed and labeled for use in residential applications. Residential ballasts must meet the technical standards for consumer RF lighting devices as specified in subpart C of 47 CFR part 18.

1.14. *RMS* is the root mean square of a varying quantity.

1.15. *Standby mode* means the condition in which an energy-using product—

(a) Is connected to a main power source; and

(b) Offers one or more of the following user-oriented or protective functions:

(i) To facilitate the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer.

(ii) Continuous functions, including information or status displays (including clocks) or sensor-based functions.

1.16. *Wireless control signal* means a wireless signal that is radiated to and received by the ballast for the purpose of controlling the ballast and putting the ballast in standby mode.

2. Active Mode Procedure

2.1. Where ANSI C82.2 (incorporated by reference; see § 430.3) references ANSI C82.1–1997, the operator shall use ANSI C82.1 (incorporated by reference; see § 430.3) for testing low-frequency ballasts and shall use ANSI C82.11 (incorporated by reference; see § 430.3) for high-frequency ballasts. In addition, when ANSI C82.2 is referenced, ANSI C78.81–2010 (incorporated by reference; see § 430.3), ANSI C82.1, ANSI C82.11–2002, and ANSI C82.13 (incorporated by reference; see § 430.3) shall be used instead of the versions listed as normative references in ANSI C82.2.

2.2. Instruments

2.2.1. All instruments shall be as specified by ANSI C82.2 (incorporated by reference; see § 430.3).

2.2.2. *Power Analyzer*. In addition to the specifications in ANSI C82.2 (incorporated by reference; see § 430.3), the power analyzer shall have a maximum 100 pF capacitance to ground and frequency response between 40 Hz and 1 MHz.

2.2.3. *Current Probe*. In addition to the specifications in ANSI C82.2 (incorporated by reference; see § 430.3), the current probe shall be galvanically isolated and have frequency response between 40 Hz and 20 MHz.

2.3. Test Setup

2.3.1. The ballast shall be connected to a main power source and to the fluorescent lamp load according to the manufacturer's wiring instructions and ANSI C82.1 (incorporated by reference; see § 430.3) and ANSI C78.81–2010 (incorporated by reference; see § 430.3).

2.3.1.1.1. Wire lengths between the ballast and fluorescent lamp shall be the length provided by the ballast manufacturer. Wires shall be kept loose and not shortened or bundled.

2.3.1.1.1.1. If the wire lengths supplied with the ballast are of insufficient length to reach both ends of lamp, additional wire may be added. The minimal additional wire length necessary shall be added, and the additional wire shall be the same wire gauge as the wire supplied with the ballast. If no wiring is provided with the ballast, 18 gauge or thicker wire shall be used. The wires shall be separated from each other and ground to prevent parasitic capacitance for all wires used in the apparatus, including those wires from the ballast to the lamps and from the lamps to the measuring devices.

2.3.1.1.2. The fluorescent lamp shall meet the specifications of a reference lamp as defined by ANSI C82.13 (incorporated by reference; see § 430.3) and be seasoned at least 12 hours.

2.3.1.2. The ballast shall be connected to the number of lamps equal to the maximum number of lamps the ballast is designed to operate.

2.3.1.3. The ballast shall be tested with a reference lamp of the nominal wattage listed in Table A of this section.

2.3.1.4. For ballasts that operate rapid-start lamps (commonly referred to as 8-foot high output lamps) with recessed double contact bases, a nominal overall length of 96 inches, and that operate at ambient temperatures of 20 °F or less and are used in outdoor signs (sign ballasts):

2.3.1.4.1. A T8 lamp in accordance with Table A of this section shall be used for sign ballasts that only operate T8 lamps.

2.3.1.4.2. A T12 lamp in accordance with Table A of this section shall be used for sign ballasts that only operate T12 lamps.

2.3.1.4.3. A T12 lamp in accordance with Table A of this section shall be used for sign ballasts that are capable of operating both T8 and T12 lamps.

TABLE A—LAMP-AND-BALLAST PAIRINGS AND FREQUENCY ADJUSTMENT FACTORS

Ballast type	Nominal lamp wattage	Lamp diameter and base	Frequency adjustment factor (β)	
			Low-frequency	High-frequency
Ballasts that operate straight-shaped lamps (commonly referred to as 4-foot medium bipin lamps) with medium bipin bases and a nominal overall length of 48 inches.	32 34	T8 MBP T12 MBP	0.94 0.93	1.0 1.0
Ballasts that operate U-shaped lamps (commonly referred to as 2-foot U-shaped lamps) with medium bipin bases and a nominal overall length between 22 and 25 inches.	32 34	T8 MBP T12 MBP	0.94 0.93	1.0 1.0
Ballasts that operate rapid-start lamps (commonly referred to as 8-foot-high output lamps) with recessed double contact bases and a nominal overall length of 96 inches.	86 95	T8 HO RDC T12 HO RDC	0.92 0.94	1.0 1.0
Ballasts that operate instant-start lamps (commonly referred to as 8-foot slimline lamps) with single pin bases and a nominal overall length of 96 inches.	59 60	T8 slimline SP T12 slimline SP	0.95 0.94	1.0 1.0
Ballasts that operate straight-shaped lamps (commonly referred to as 4-foot miniature bipin standard output lamps) with miniature bipin bases and a nominal length between 45 and 48 inches.	28	T5 SO Mini-BP	0.95	1.0
Ballasts that operate straight-shaped lamps (commonly referred to as 4-foot miniature bipin high output lamps) with miniature bipin bases and a nominal length between 45 and 48 inches.	54	T5 HO Mini-BP	0.95	1.0
Ballasts that operate rapid-start lamps (commonly referred to as 8-foot high output lamps) with recessed double contact bases, a nominal overall length of 96 inches, and that operate at ambient temperatures of 20 °F or less and are used in outdoor signs.	86 110	T8 HO RDC T12 HO RDC	0.92 0.94	1.0 1.0

MBP, Mini-BP, RDC, and SP represent medium bipin, miniature bipin, recessed double contact, and single pin, respectively.

2.3.2. Power Analyzer

2.3.2.1. The power analyzer shall have n+1 channels where n is the number of lamps a ballast operates.

2.3.2.2. *Lamp Arc Voltage*. Leads from the power analyzer should attach to each fluorescent lamp according to Figure 1 of this section for rapid- and programmed-start ballasts, Figure 2 of this section for instant-start ballasts operating single pin (SP) lamps, and Figure 3 of this section for instant-start ballasts operating medium bipin (MBP), miniature bipin (mini-BP), or recessed double contact (RDC) lamps. The programmed- and rapid-start ballast test setup includes two 1000 ohm resistors placed in parallel with the lamp pins to create a midpoint from which to measure lamp arc voltage.

2.3.2.3. *Lamp Arc Current*. A current probe shall be positioned on each fluorescent lamp according to Figure 1 for rapid- and programmed-start ballasts, Figure 2 of this section for instant-start ballasts operating SP lamps, and Figure 3 of this section for instant-start ballasts operating MBP, mini-BP, and RDC lamps.

2.3.2.3.1. For the lamp arc current measurement, the full transducer ratio shall be set in the power analyzer to match the current probe to the power analyzer.

$$\text{Full Transducer Ratio} = \frac{I_{in}}{V_{out}} \times \frac{R_{in}}{R_{in} + R_s}$$

Where:

I_{in} Current through the current transducer

V_{out} Voltage out of the transducer

R_{in} Power analyzer impedance

R_s Current probe output impedance

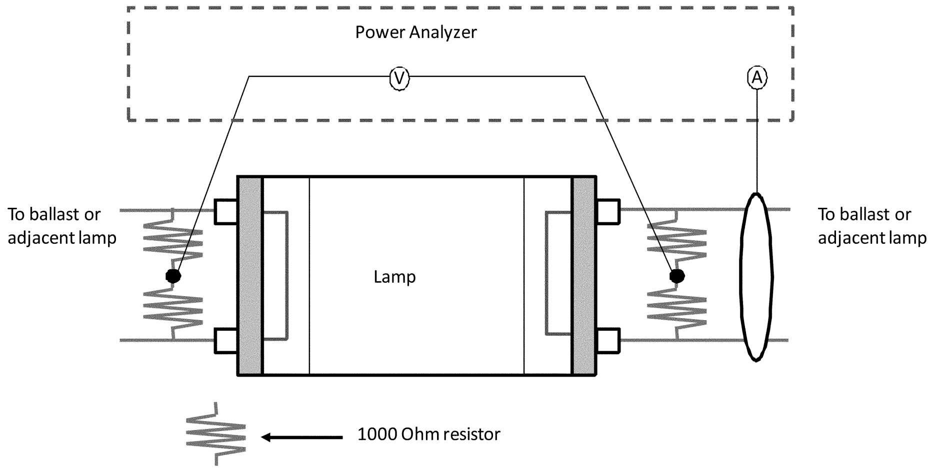


Figure 1: Programmed- and Rapid-Start Ballast Instrumentation Setup

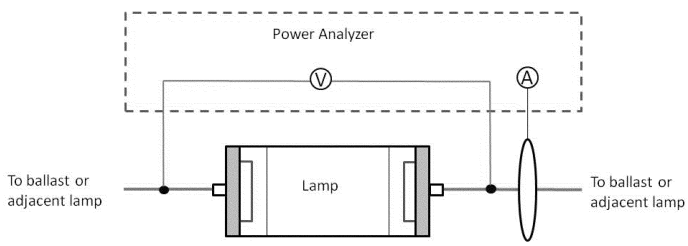


Figure 2: Instant-Start Ballasts that Operate SP Lamps Instrumentation Setup

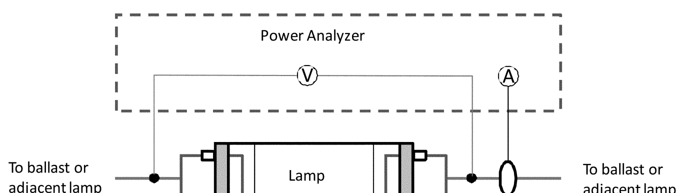


Figure 3: Instant-Start Ballasts that Operate MBP, mini-BP, and RDC Lamps Instrumentation Setup

2.4. Test Conditions

2.4.1. The test conditions for testing fluorescent lamp ballasts shall be done in accordance with ANSI C82.2 (incorporated by reference; see § 430.3). DOE further specifies that the following revisions of the normative references indicated in ANSI C82.2) should be used in place of the references directly specified in ANSI C82.2: ANSI C78.81–2010 (incorporated by reference; see § 430.3), ANSI C82.1 (incorporated by reference; see § 430.3), ANSI C82.3 (incorporated by reference; see § 430.3), ANSI C82.11 (incorporated by reference; see § 430.3), and ANSI C82.13 (incorporated by reference; see § 430.3). All other normative references shall be as specified in ANSI C82.2.

2.4.2. *Room Temperature and Air Circulation.* The test facility shall be held at 25 ± 2 °C, with minimal air movement as defined in ANSI C78.375 (incorporated by reference; see § 430.3).

2.4.3. *Input Voltage.* The directions in ANSI C82.2 (incorporated by reference; see § 430.3) section 4.1 should be ignored with the following directions for input voltage used instead. For commercial ballasts capable of operating at multiple voltages, the ballast shall be tested 277V ± 0.1%. For ballasts designed and labeled for residential applications and capable of operating at multiple voltages, the ballast shall be tested at 120V ± 0.1%. For ballasts designed and labeled as cold-temperature outdoor sign ballasts and capable of operating at multiple voltages, the ballast shall be tested at 120V ± 0.1%. Ballasts capable of operating at only one input voltage shall be tested at that specified voltage.

2.5. Test Method

2.5.1. *Ballast Luminous Efficiency.*

2.5.1.1. The ballast shall be connected to the appropriate fluorescent lamps and to measurement instrumentation as indicated by the Test Setup in section 2.3.

2.5.1.2. The ballast shall be operated at full output for at least 15 minutes but no longer than 1 hour until stable operating conditions are reached. After this condition is reached, concurrently measure the parameters described in sections 2.5.1.3 through 2.5.1.9.

2.5.1.2.1. Stable operating conditions are determined by measuring lamp arc voltage, current, and power once per second in accordance with the setup described in section 2.3. Once the difference between the maximum and minimum values for lamp arc voltage, current, and power do not exceed one percent over a four minute moving window, the system shall be considered stable.

2.5.1.3. *Lamp Arc Voltage.* Measure lamp arc voltage (volts) using the setup described in section 2.3.2.2.

2.5.1.4. *Lamp Arc Current.* Measure lamp arc current (amps) using the setup described in section 2.3.2.3.

2.5.1.5. *Lamp Arc Power.* The power analyzer shall calculate output power by using the measurements described in sections 2.5.1.3 and 2.5.1.4.

2.5.1.6. *Input Power.* Measure the input power (watts) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see §430.3), section 7.

2.5.1.7. *Input Voltage.* Measure the input voltage (volts) (RMS) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see §430.3), section 3.2.1 and section 4.

2.5.1.8. *Input Current.* Measure the input current (amps) (RMS) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see §430.3), section 3.2.1 and section 4.

2.5.1.9. *Lamp Operating Frequency.* Measure the frequency of the waveform delivered from the ballast to any lamp in accordance with the setup in section 2.3.

2.6. Calculations

2.6.1. Calculate ballast luminous efficiency (BLE).

$$\text{Ballast Luminous Efficiency} = \frac{\text{Total Test Ballast Lamp Arc Power}}{\text{Ballast Input Power}} * \beta$$

Where: Total Lamp Arc Power is the sum of the lamp arc powers for all lamps operated by the ballast as determined by section 2.5.1.5, ballast input power is as determined by section 2.5.1.6, and β is equal to the frequency adjustment factor in Table A.

2.6.2. Calculate Power Factor (PF).

$$\text{Power Factor} = \frac{\text{Ballast Input Power} \times \text{Input Voltage}}{\text{Input Current}}$$

Where: Ballast input power is determined in accordance with section 2.5.1.6, input voltage is determined in accordance with section 2.5.1.7, and input current in determined in accordance with section 2.5.1.8.

3. Standby Mode Procedure

3.1. The measurement of standby mode power need not be performed to determine compliance with energy conservation standards for fluorescent lamp ballasts at this time. The above statement will be removed as part of a rulemaking to amend the energy conservation standards for fluorescent lamp ballasts to account for standby mode energy consumption, and the following shall apply on the compliance date for such requirements.

3.2. Test Conditions

3.2.1. The test conditions for testing fluorescent lamp ballasts shall be done in accordance with the American National Standard Institute ANSI C82.2 (incorporated by reference; see § 430.3). Any subsequent amendment to this standard by the standard-setting organization will not affect the DOE test procedures unless and until amended by DOE. The test conditions for measuring standby power are described in sections 5, 7, and 8 of ANSI C82.2. Fluorescent lamp ballasts that are capable of connections to control devices shall be tested with all commercially available compatible control devices connected in all possible configurations. For each configuration, a separate measurement of standby power shall be made in accordance with section 3.3 of the test procedure.

3.3. Test Method and Measurements

3.3.1. The test for measuring standby mode energy consumption of fluorescent lamp ballasts shall be done in accordance with ANSI C82.2 (incorporated by reference; see § 430.3).

3.3.2. Send a signal to the ballast instructing it to have zero light output using the appropriate ballast communication protocol or system for the ballast being tested.

3.3.3. *Input Power*. Measure the input power (watts) to the ballast in accordance with ANSI C82.2, section 13, (incorporated by reference; see § 430.3).

3.3.4. *Control Signal Power*. The power from the control signal path will be measured using all applicable methods described below.

3.3.4.1. *AC Control Signal*. Measure the AC control signal power (watts), using a wattmeter (W), connected to the ballast in accordance with the circuit shown in Figure 4 of this section.

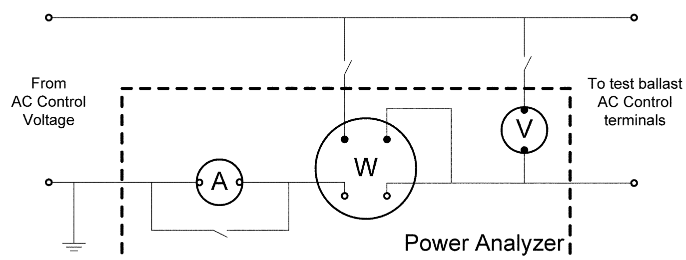


Figure 4: Circuit for Measuring AC Control Signal Power in Standby Mode

3.3.4.2. *DC Control Signal*. Measure the DC control signal voltage, using a voltmeter (V), and current, using an ammeter (A), connected to the ballast in accordance with the circuit shown in Figure 5 of this section. The DC control signal power is calculated by multiplying the DC control signal voltage and the DC control signal current.

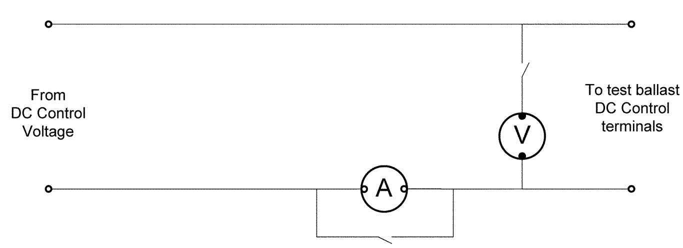


Figure 5: Circuit for Measuring DC Control Signal Power in Standby Mode

3.3.4.3. *Power Line Carrier (PLC) Control Signal*. Measure the PLC control signal power (watts), using a wattmeter (W), connected to the ballast in accordance with the circuit shown in Figure 6 of this section. The wattmeter must have a frequency response that is at least 10 times higher than the PLC being measured in order to measure the PLC signal correctly. The wattmeter must also be high-pass filtered to filter out power at 60 Hertz.

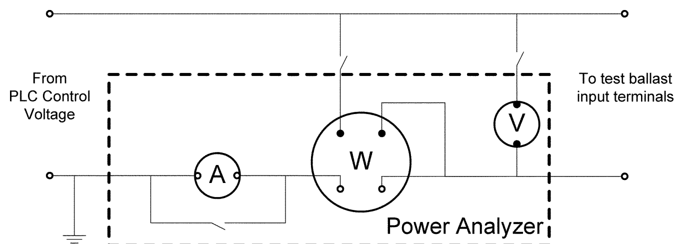


Figure 6: Circuit for Measuring PLC Control Signal Power in Standby Mode

3.3.4.4. *Wireless Control Signal*. The power supplied to a ballast using a wireless signal is not easily measured, but is estimated to be well below 1.0 watt. Therefore, the wireless control signal power is not measured as part of this test procedure.

[76 FR 25224, May 4, 2011]

EFFECTIVE DATE NOTE: At 76 FR 70628, Nov. 14, 2011, appendix Q1 to subpart B of part 430 was amended by adding introductory text after the heading, effective Jan. 13, 2012. For the convenience of the user, the added text is set forth as follows:

APPENDIX Q1 TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FLUORESCENT LAMP BALLASTS

Comply with appendix Q1 beginning November 14, 2014. Prior to this date, all fluorescent lamp ballasts shall be tested using the provisions of appendix Q.

* * * * *

APPENDIX R TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING AVERAGE LAMP EFFICACY (LE), COLOR RENDERING INDEX (CRI), AND CORRELATED COLOR TEMPERATURE (CCT) OF ELECTRIC LAMPS

1. *Scope:* This appendix applies to the measurement of lamp lumens, electrical characteristics, CRI, and CCT for general service fluorescent lamps, and to the measurement of lamp lumens, electrical characteristics for general service incandescent lamps and incandescent reflector lamps.

2. *Definitions*

2.1 To the extent that definitions in the referenced IESNA and CIE standards do not conflict with the DOE definitions, the definitions specified in section 1.2 of IESNA LM–9 (incorporated by reference; see §430.3), section 3.0 of IESNA LM–20 (incorporated by reference; see §430.3), section 1.2 and the Glossary of IESNA LM–45 (incorporated by reference; see §430.3), section 2 of IESNA LM–58 (incorporated by reference; see §430.3), and appendix 1 of CIE 13.3 (incorporated by reference; see §430.3) shall be included.

2.2 *ANSI Standard* means a standard developed by a committee accredited by the American National Standards Institute (ANSI).

2.3 *CIE* means the International Commission on Illumination.

2.4 *CRI* means Color Rendering Index as defined in §430.2.

2.5 *IESNA* means the Illuminating Engineering Society of North America.

2.6 *Lamp efficacy* means the ratio of measured lamp lumen output in lumens to the measured lamp electrical power input in watts, rounded to the nearest tenth, in units of lumens per watt.

2.7 *Lamp lumen output* means the total luminous flux produced by the lamp, at the reference condition, in units of lumens.

2.8 *Lamp electrical power input* means the total electrical power input to the lamp, including both arc and cathode power where appropriate, at the reference condition, in units of watts.

2.9 *Reference condition* means the test condition specified in IESNA LM–9 for general service fluorescent lamps, in IESNA LM–20 for incandescent reflector lamps, in IESNA LM–45 for general service incandescent lamps (incorporated by reference; see §430.3).

3. Test Conditions

3.1 *General Service Fluorescent Lamps:* For general service fluorescent lamps, the ambient conditions of the test and the electrical circuits, reference ballasts, stabilization requirements, instruments, detectors, and photometric test procedure and test report shall be as described in the relevant sections of IESNA LM–9 (incorporated by reference; see §430.3).

3.2 *General Service Incandescent Lamps:* For general service incandescent lamps, the selection and seasoning (initial burn-in) of the test lamps, the equipment and instrumentation, and the test conditions shall be as described in IESNA LM–45 (incorporated by reference; see §430.3).

3.3 *Incandescent Reflector Lamps:* For incandescent reflector lamps, the selection and seasoning (initial burn-in) of the test lamps, the equipment and instrumentation, and the test conditions shall conform to sections 4.2 and 5.0 of IESNA LM–20 (incorporated by reference; see §430.3).

4. Test Methods and Measurements

All lumen measurements made with instruments calibrated to the devalued NIST lumen after January 1, 1996, shall be multiplied by 1.011.

4.1 *General Service Fluorescent Lamps*

4.1.1 The measurement procedure shall be as described in IESNA LM–9 (incorporated by reference; see §430.3), except that lamps shall be operated at the appropriate voltage and current conditions as described in ANSI C78.375 (incorporated by reference; see §430.3) and in ANSI C78.81 (incorporated by reference; see §430.3) or ANSI C78.901 (incorporated by reference; see §430.3), and lamps shall be operated using the appropriate reference ballast at input voltage specified by the reference circuit as described in ANSI C82.3 (incorporated by reference; see §430.3). If, for a lamp, both low-frequency and high-frequency reference ballast settings are included in ANSI C78.81 or ANSI C78.901, the lamp shall be operated using the low-frequency reference ballast.

4.1.2 For lamps not listed in ANSI C78.81 (incorporated by reference; see §430.3) nor in ANSI C78.901 (incorporated by reference; see §430.3), the lamp shall be operated using the following reference ballast settings:

4.1.2.1 4-Foot medium bi-pin lamps shall be operated using the following reference ballast settings: T10 or T12 lamps are to use 236 volts, 0.43 amps, and 439 ohms; T8 lamps are to use 300 volts, 0.265 amps, and 910 ohms.

4.1.2.2 2-Foot U-shaped lamps shall be operated using the following reference ballast settings: T12 lamps are to use 236 volts, 0.430 amps, and 439 ohms; T8 lamps are to use 300 volts, 0.265 amps, and 910 ohms.

4.1.2.3 8-foot slimline lamps shall be operated using the following reference ballast settings:

(a) *T12 lamps:* 625 volts, 0.425 amps, and 1280 ohms.

(b) *T8 lamps:* 625 volts, 0.260 amps, and 1960 ohms.

4.1.2.4 8-foot high output lamps shall be operated using the following reference ballast settings:

(a) *T12 lamps:* 400 volts, 0.800 amps, and 415 ohms.

(b) *T8 lamps:* 450 volts, 0.395 amps, and 595 ohms.

4.1.2.5 4-foot miniature bipin standard output or high output lamps shall be operated using the following reference ballast settings:

(a) *Standard Output:* 329 volts, 0.170 amps, and 950 ohms.

(b) *High Output:* 235 volts, 0.460 amps, and 255 ohms.

4.1.3 Lamp lumen output (lumens) and lamp electrical power input (watts), at the reference condition, shall be measured and recorded. Lamp efficacy shall be determined by computing the ratio of the measured lamp lumen output and lamp electrical power input at equilibrium for the reference condition.

4.2 *General Service Incandescent Lamps*

4.2.1 The measurement procedure shall be as described in IESNA LM–45 (incorporated by reference; see §430.3). Lamps shall be operated at the rated voltage as defined in §430.2.

4.2.2 The test procedure shall conform with sections 5 and 9 of IESNA LM–45 (incorporated by reference; see §430.3), and the lumen output of the lamp shall be determined in accordance with section 9 of IESNA LM–45. Lamp electrical power input in watts shall be measured and recorded. Lamp efficacy shall be determined by computing the ratio of the measured lamp lumen output and lamp electrical power input at equilibrium for the reference condition. The test report shall conform to section 11 of IESNA LM–45.

4.3 *Incandescent Reflector Lamps*

4.3.1 The measurement procedure shall be as described in IESNA LM–20 (see 10 CFR 430.22). Lamps shall be operated at the rated voltage as defined in §430.2.

4.3.2. Lamp lumen output shall be determined as total forward lumens, and may be measured in an integrating sphere at the reference condition in accordance with §7.2 of IESNA LM–20 (incorporated by reference; see §430.3) or from an average intensity distribution curve measured at the reference condition specified in §6.0 of IESNA LM–20. Lamp electrical power input in watts shall be measured and recorded.

4.3.3 Lamp efficacy shall be determined by computing the ratio of the measured lamp lumen output and lamp electrical power input at equilibrium for the reference condition. The test report shall conform to section 10.0 of IES LM–20 (incorporated by reference; see §430.3).

4.4 Determination of Color Rendering Index and Correlated Color Temperature

4.4.1 The CRI shall be determined in accordance with the method specified in CIE 13.3 (incorporated by reference; see §430.3) for general service fluorescent lamps. The CCT shall be determined in accordance with the method specified in IESNA LM–9 (incorporated by reference; see §430.3) and rounded to the nearest 10 kelvin for general service fluorescent lamps. The CCT shall be determined in accordance with the CIE 15 (incorporated by reference; see §430.3) for incandescent lamps. The required spectroradiometric measurement and characterization shall be conducted in accordance with the methods set forth in IESNA LM–58 (incorporated by reference; see §430.3).

4.4.2 The test report shall include a description of the test conditions, equipment, measured lamps, spectroradiometric measurement results, and CRI and CCT determinations.

4.5 *Determination of Color Rendering Index*

4.5.1 The CRI shall be determined in accordance with the method specified in CIE Publication 13.2 for general service fluorescent lamps. The required spectroradiometric measurement and characterization shall be conducted in accordance with the methods given in IESNA LM–58 and IESNA LM–16 (see 10 CFR 430.22).

4.5.2 The test report shall include a description of the test conditions, equipment, measured lamps, spectroradiometric measurement results and CRI determination.

[62 FR 29240, May 29, 1997, as amended at 74 FR 34177, July 14, 2009]

APPENDIX S TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE WATER CONSUMPTION OF FAUCETS AND SHOWERHEADS

1. *Scope:* This appendix covers the test requirements used to measure the hydraulic performance of faucets and showerheads.

2. Flow Capacity Requirements:

a. Faucets—The test procedures to measure the water flow rate for faucets, expressed in gallons per minute (gpm) and liters per minute (L/min), or gallons per cycle (gal/cycle) and liters per cycle (L/cycle), shall be conducted in accordance with the test requirements specified in section 6.5, Flow Capacity Test, of the ASME/ANSI Standard A112.18.1M–1996 (see §430.22). Measurements shall be recorded at the resolution of the test instrumentation. Calculations shall be rounded off to the same number of significant digits as the previous step. The final water consumption value shall be rounded to one decimal place for non-metered faucets, or two decimal places for metered faucets.

b. Showerheads—The test conditions to measure the water flow rate for showerheads, expressed in gallons per minute (gpm) and liters per minute (L/min), shall be conducted in accordance with the test requirements specified in section 6.5, Flow Capacity Test, of the ASME/ANSI Standard A112.18.1M–1996 (see §430.22). Measurements shall be recorded at the resolution of the test instrumentation. Calculations shall be rounded off to the same number of significant digits as the previous step. The final water consumption value shall be rounded to one decimal place.

[63 FR 13316, Mar. 18, 1998]

APPENDIX T TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE WATER CONSUMPTION OF WATER CLOSETS AND URINALS

1. *Scope:* This appendix covers the test requirements used to measure the hydraulic performances of water closets and urinals.

2. Test Apparatus and General Instructions:

a. The test apparatus and instructions for testing water closets shall conform to the requirements specified in section 7.1.2, Test Apparatus and General Requirements, subsections 7.1.2.1, 7.1.2.2, and 7.1.2.3 of the ASME/ANSI Standard A112.19.6–1995 (see §430.22). Measurements shall be recorded at the resolution of the test instrumentation. Calculations shall be rounded off to the same number of significant digits as the previous step. The final water consumption value shall be rounded to one decimal place.

b. The test apparatus and instructions for testing urinals shall conform to the requirements specified in section 8.2, Test Apparatus and General Requirements, subsections 8.2.1, 8.2.2, and 8.2.3 of the ASME/ANSI Standard A112.19.6–1995 (see §430.22). Measurements shall be recorded at the resolution of the test instrumentation. Calculations shall be rounded off to the same number of significant digits as the previous step. The final water consumption value shall be rounded to one decimal place.

3. Test Measurement:

a. Water closets—The measurement of the water flush volume for water closets, expressed in gallons per flush (gpf) and liters per flush (Lpf), shall be conducted in accordance with the test requirements specified in section 7.1.6, Water Consumption and Hydraulic Characteristics, of the ASME/ANSI Standard A112.19.6–1995 (see § 430.22).

b. Urinals—The measurement of water flush volume for urinals, expressed in gallons per flush (gpf) and liters per flush (Lpf), shall be conducted in accordance with the test requirements specified in section 8.5, Water Consumption, of the ASME/ANSI Standard A112.19.6–1995 (see § 430.22).

[63 FR 13317, Mar. 18, 1998]

APPENDIX U TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF CEILING FANS

1. *Scope*. This appendix covers the test requirements used to measure the energy performance of ceiling fans.

2. *Definitions:*

a. *Airflow* means the rate of air movement at a specific fan-speed setting expressed in cubic feet per minute (CFM).

b. *Airflow efficiency* means the ratio of airflow divided by power at a specific ceiling fan-speed setting expressed in CFM per watt (CFM/watt).

3. *Test Apparatus and General Instructions:* The test apparatus and instructions for testing ceiling fans shall conform to the requirements specified in Chapter 3, ''Air-Delivery Room Construction and Preparation,'' Chapter 4, ''Equipment Set-up and Test Procedure,'' and Chapter 6, ''Definitions and Acronyms,'' of the EPA's ''ENERGY STAR Testing Facility Guidance Manual: Building a Testing Facility and Performing the Solid State Test Method for ENERGY STAR Qualified Ceiling Fans,'' Version 1.1, December 9, 2002 (Incorporated by reference, see § 430.22). Record measurements at the resolution of the test instrumentation. Round off calculations to the same number of significant digits as the previous step. Round the final energy consumption value to the nearest whole number as follows:

(i) A fractional number at or above the midpoint between the two consecutive whole numbers shall be rounded up to the higher of the two whole numbers; or

(ii) A fractional number below the midpoint between the two consecutive whole numbers shall be rounded down to the lower of the two whole numbers.

4. *Test Measurement:* Measure the airflow and airflow efficiency for ceiling fans, expressed in cubic feet per minute (CFM) and CFM per watt (CFM/watt), in accordance with the test requirements specified in Chapter 4, ''Equipment Setup and Test Procedure,'' of the EPA's ''ENERGY STAR Testing Facility Guidance Manual: Building a Testing Facility and Performing the Solid State Test Method for ENERGY STAR Qualified Ceiling Fans,'' Version 1.1, December 9, 2002 (Incorporated by reference, see § 430.22). In performing the airflow test, measure ceiling fan power using a RMS sensor capable of measuring power with an accuracy of ±1 %. Prior to using the sensor and sensor software it has selected, the test laboratory shall verify performance of the sensor and sensor software. Measure power input at a point that includes all power consuming components of the ceiling fan (but without any attached light kit energized). Measure power at the rated voltage that represents normal operation continuously over the time period for which the airflow test is conducted, and report the average value of the power measurement in watts (W). Use the average value of power input to calculate the airflow efficiency in CFM/W.

[71 FR 71366, Dec. 8, 2006]

APPENDIX V TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF CEILING FAN LIGHT KITS

1. *Scope:* This appendix covers the test requirements used to measure the energy performance of ceiling fan light kits.

2. *Definitions:*

a. *Input power* means the actual total power used by all lamp(s) and ballast(s) of the light kit during operation, expressed in watts (W) and measured using the lamp and ballast packaged with the kit.

b. *Lamp ballast platform* means a pairing of one ballast with one or more lamps that can operate simultaneously on that ballast. A unique platform is defined by the manufacturer and model number of the ballast and lamp(s) and the quantity of lamps that operate on the ballast.

c. *Lamp lumens* means a measurement of luminous flux expressed in lumens and measured using the lamp and ballast shipped with the fixture.

d. *System efficacy per lamp ballast platform* means the ratio of measured lamp lumens expressed in lumens and measured input power expressed in watts (W).

3. *Test Apparatus and General Instructions:*

(a) The test apparatus and instruction for testing screw base lamps packaged with ceiling fan light kits that have medium screw base sockets shall conform to the requirements specified in section 2, ''Definitions,'' section 3, ''Referenced Standards,'' and section 4, ''CFL Requirements for Testing'' of DOE's ''ENERGY STAR Program Requirements for [Compact Fluorescent Lamps] CFLs,'' Version 3.0, (Incorporated by reference, see § 430.22). Record measurements at the resolution of the test instrumentation. Round off calculations to the same number of significant digits as the previous step. Round off the final energy consumption value to a whole number as follows:

(i) A fractional number at or above the midpoint between the two consecutive whole numbers shall be rounded up to the higher of the two whole numbers; or

(ii) A fractional number below the midpoint between the two consecutive whole numbers shall be rounded down to the lower of the two whole numbers.

(b) The test apparatus and instruction for testing pin-based fluorescent lamps packaged with ceiling fan light kits that have pin-based sockets shall conform to the requirements specified in section 1, ''Definitions,'' and section 3, ''Energy Efficiency Specifications for Qualifying Products'' of the EPA's ''ENERGY STAR Program Requirements for Residential Light Fixtures,'' Version 4.0, (Incorporated by reference, see § 430.22). Record measurements at the resolution of the test instrumentation. Round off calculations to the same number of significant digits as the previous step. The final energy consumption value shall be rounded to a whole number as follows:

(i) A fractional number at or above the midpoint between the two consecutive whole numbers shall be rounded up to the higher of the two whole numbers; or

(ii) A fractional number below the midpoint between the two consecutive whole numbers shall be rounded down to the lower of the two whole numbers.

4. *Test Measurement:*

(a) For screw base compact fluorescent lamps packaged with ceiling fan light kits that have medium screw base sockets, measure the efficacy, expressed in lumens per watt, in accordance with the test requirements specified in section 4, ''CFL Requirements for Testing,'' of the ''ENERGY STAR Program Requirements for Compact Fluorescent Lamps,'' Version 3.0 (Incorporated by reference, see § 430.22).

(b) For pin-based compact fluorescent lamps packaged with ceiling fan light kits that have pin-based sockets, measure the efficacy, expressed in lumens per watt, in accordance with the test requirements specified in section 3, ''Energy-Efficiency Specifications for Qualifying Products'' and Table 3 in section 4, ''Qualification Process, Testing Facilities, Standards, and Documentation,'' of the ''ENERGY STAR Program Requirements for Residential Light Fixtures,'' Version 4.0 (Incorporated by reference, see § 430.22).

[71 FR 71366, Dec. 8, 2006]

APPENDIX W TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF MEDIUM BASE COMPACT FLUORESCENT LAMPS

1. *Scope:* This appendix covers the test requirements used to measure the initial efficacy, lumen maintenance at 1,000 hours, lumen maintenance at 40 percent of rated life, rapid cycle stress, and lamp life of medium base compact fluorescent lamps.

2. *Definitions:*

a. *Average rated life* means the length of time declared by the manufacturer at which 50 percent of any large number of units of a lamp reaches the end of their individual lives.

b. *Initial performance values* means the photometric and electrical characteristics of the lamp at the end of 100 hours of operation. Such values include the initial efficacy, the rated luminous flux and the rated lumen output.

c. *Lumen maintenance* means the luminous flux or lumen output at a given time in the life of the lamp and expressed as a percentage of the rated luminous flux or rated lumen output, respectively.

d. *Rated luminous flux or rated lumen output* means the initial lumen rating (100 hour) declared by the manufacturer, which consists of the lumen rating of a lamp at the end of 100 hours of operation.

e. *Rated supply frequency* means the frequency marked on the lamp.

f. *Rated voltage* means the voltage marked on the lamp.

g. *Rated wattage* means the wattage marked on the lamp.

h. *Self-ballasted compact fluorescent lamp* means a compact fluorescent lamp unit that incorporates, permanently enclosed, all elements that are necessary for the starting and stable operation of the lamp, and does not include any replaceable or interchangeable parts.

3. *Test Apparatus and General Instructions:* The test apparatus and instructions for testing medium base compact fluorescent lamps shall conform to the requirements specified in section 2, ''Definitions,'' section 3, ''Referenced Standards,'' and section 4, ''CFL Requirements for Testing,'' of DOE's ''ENERGY STAR Program Requirements for [Compact Fluorescent Lamps] CFLs,'' Version dated August 9, 2001, (commonly referred to as Version 2.0), (Incorporated by reference, see § 430.22). Record measurements at the resolution of the test instrumentation. Round off calculations to the same number of significant digits as the previous step. Round the final energy consumption value, as applicable, to the nearest decimal place or whole number as follows:

(i) A fractional number at or above the midpoint between two consecutive decimal places or whole numbers shall be rounded up to the higher of the two decimal places or whole numbers; or

(ii) A fractional number below the midpoint between two consecutive decimal places or whole numbers shall be rounded down to the lower of the two decimal places or whole numbers. Round the final initial efficacy to one decimal place. Round the final lumen maintenance at 1,000 hours to a whole number. Round the final lumen maintenance at 40 percent of rated life, the final rapid cycle stress, and the final lamp life for medium base compact fluorescent lamps to whole numbers.

4. *Test Measurement:* Measure the initial efficacy expressed in lumens per watt; lumen maintenance at 1,000 hours expressed in lumens; lumen maintenance at 40 percent of rated life expressed in lumens; rapid cycle stress expressed in the number of lamps that meet or exceed the minimum number of cycles; and lamp life expressed in hours in accordance with the test requirements specified in section 4, ''CFL Requirements for Testing'' of DOE's ''ENERGY STAR Program Requirements for [Compact Fluorescent Lamps] CFLs,'' Version dated August 9, 2001 (Incorporated by reference, see §430.22).

[71 FR 71366, Dec. 8, 2006]

Appendix X to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Dehumidifiers

1. *Scope:* This appendix covers the test requirements used to measure the energy performance of dehumidifiers.

2. *Definitions:*

a. *Product capacity for dehumidifiers* means a measure of the ability of a dehumidifier to remove moisture from its surrounding atmosphere, measured in pints collected per 24 hours of continuous operation.

b. *Energy factor for dehumidifiers* means a measure of energy efficiency of a dehumidifier calculated by dividing the water removed from the air by the energy consumed, measured in liters per kilowatt hour (L/kWh).

3. *Test Apparatus and General Instructions:* The test apparatus and instructions for testing dehumidifiers shall conform to the requirements specified in section 1, ''Definitions,'' section 2, ''Qualifying Products,'' and section 4, ''Test Criteria,'' of the EPA's ''ENERGY STAR Program Requirements for Dehumidifiers,'' effective January 1, 2001 (Incorporated by reference, see §430.22). Record measurements at the resolution of the test instrumentation. Round off calculations to the same number of significant digits as the previous step. Round the final minimum energy factor value to two decimal places as follows:

(i) A fractional number at or above the midpoint between two consecutive decimal places shall be rounded up to the higher of the two decimal places; or

(ii) A fractional number below the midpoint between two consecutive decimal places shall be rounded down to the lower of the two decimal places.

4. *Test Measurement:* Measure the energy factor for dehumidifiers, expressed in liters per kilowatt hour (L/kWh) and product capacity in pints per day (pints/day), in accordance with the test requirements specified in section 4, ''Test Criteria,'' of EPA's ''ENERGY STAR Program Requirements for Dehumidifiers,'' effective January 1, 2001 (Incorporated by reference, see §430.22).

[71 FR 71366, Dec. 8, 2006]

Appendix Y to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Battery Chargers

The provisions of this appendix are effective on the compliance date of any energy conservation standard for battery chargers.

1. Scope

This appendix covers the test requirements used to measure battery charger energy consumption for battery chargers operating at either DC or United States AC line voltage (115V at 60Hz).

2. Definitions

The following definitions are for the purposes of explaining the terminology associated with the test method for measuring battery charger energy consumption.[1]

2.1. *Active mode* or *charge mode* is the state in which the battery charger system is connected to the main electricity supply, and the battery charger is delivering current, equalizing the cells, and performing other one-time or limited-time functions in order to bring the battery to a fully charged state.

2.2. *Active power* or *real power* (P) means the average power consumed by a unit. For a two terminal device with current and voltage waveforms i(t) and v(t), which are periodic with period T, the real or active power P is:

$$P = \frac{1}{T}\int_0^T v(t)i(t)dt$$

2.3. *Ambient temperature* is the temperature of the ambient air immediately surrounding the unit under test.

2.4. *Apparent power* (S) is the product of root-mean-square (RMS) voltage and RMS current in volt-amperes (VA).

2.5. *Batch charger* is a battery charger that charges two or more identical batteries simultaneously in a series, parallel, series-parallel, or parallel-series configuration. A batch charger does not have separate voltage

[1] For clarity on any other terminology used in the test method, please refer to IEEE Standard 1515–2000.

or current regulation, nor does it have any separate indicators for each battery in the batch. When testing a batch charger, the term "battery" is understood to mean, collectively, all the batteries in the batch that are charged together. A charger can be both a batch charger and a multi-port charger or multi-voltage charger.

2.6. *Battery* or *battery pack* is an assembly of one or more rechargeable cells and any integral protective circuitry intended to provide electrical energy to a consumer product, and may be in one of the following forms: (a) Detachable battery (a battery that is contained in a separate enclosure from the consumer product and is intended to be removed or disconnected from the consumer product for recharging); or (b) integral battery (a battery that is contained within the consumer product and is not removed from the consumer product for charging purposes). The word "intended" in this context refers to the whether a battery has been designed in such a way as to permit its removal or disconnection from its associated consumer product.

2.7. *Battery energy* is the energy, in watt-hours, delivered by the battery under the specified discharge conditions in the test procedure.

2.8. *Battery maintenance mode* or *maintenance mode* is the mode of operation when the battery charger is connected to the main electricity supply and the battery is fully charged, but is still connected to the charger.

2.9. *Battery rest period* is a period of time between discharge and charge or between charge and discharge, during which the battery is resting in an open-circuit state in ambient air.

2.10. *C-rate* is the rate of charge or discharge, calculated by dividing the charge or discharge current by the rated charge capacity of the battery.

2.11. *Cradle* is an electrical interface between an integral battery product and the rest of the battery charger designed to hold the product between uses.

2.12. *Equalization* is a process whereby a battery is overcharged, beyond what would be considered "normal" charge return, so that cells can be balanced, electrolyte mixed, and plate sulfation removed.

2.13. *Instructions* or *manufacturer's instructions* means the documentation packaged with a product in printed or electronic form and any information about the product listed on a Web site maintained by the manufacturer and accessible by the general public at the time of the test. It also includes any information on the packaging or on the product itself. "Instructions" also includes any service manuals or data sheets that the manufacturer offers to independent service technicians, whether printed or in electronic form.

2.14. *Measured charge capacity* of a battery is the product of the discharge current in amperes and the time in decimal hours required to reach the specified end-of-discharge voltage.

2.15. *Manual on-off switch* is a switch activated by the user to control power reaching the battery charger. This term does not apply to any mechanical, optical, or electronic switches that automatically disconnect mains power from the battery charger when a battery is removed from a cradle or charging base, or for products with non-detachable batteries that control power to the product itself.

2.16. *Multi-port charger* means a battery charger that charges two or more batteries (which may be identical or different) simultaneously. The batteries are not connected in series or in parallel but with each port having separate voltage and/or current regulation. If the charger has status indicators, each port has its own indicator(s). A charger can be both a batch charger and a multi-port charger if it is capable of charging two or more batches of batteries simultaneously and each batch has separate regulation and/or indicator(s).

2.17. *Multi-voltage charger* is a battery charger that, by design, can charge a variety of batteries (or batches of batteries, if also a batch charger) that are of different rated battery voltages. A multi-voltage charger can also be a multi-port charger if it can charge two or more batteries simultaneously with independent voltage and/or current regulation.

2.18. *Off mode* is the condition, applicable only to units with manual on-off switches, in which the battery charger:

(1) Is connected to the main electricity supply;

(2) Is not connected to the battery; and

(3) All manual on-off switches are turned off.

2.19. *Rated battery voltage* is specified by the manufacturer and typically printed on the label of the battery itself. If there are multiple batteries that are connected in series, the rated battery voltage of the batteries is the total voltage of the series configuration—that is, the rated voltage of each battery multiplied by the number of batteries connected in series. Connecting multiple batteries in parallel does not affect the rated battery voltage.

2.20. *Rated charge capacity* is the capacity claimed by a manufacturer, on a label or in instructions, the battery can store under specified test conditions, usually given in ampere-hours (Ah) or milliampere-hours (mAh) and typically printed on the label of the battery itself. If there are multiple batteries that are connected in parallel, the rated charge capacity of the batteries is the total charge capacity of the parallel configuration, that is, the rated charge capacity of each battery multiplied by the number of batteries connected in parallel. Connecting multiple batteries in series does not affect the rated charge capacity.

2.21. *Rated energy capacity* means the product (in watt-hours) of the rated battery voltage and the rated charge capacity.

2.22. *Standby mode* or *no-battery mode* means the condition in which:

(1) The battery charger is connected to the main electricity supply;

(2) The battery is not connected to the charger; and

(3) For battery chargers with manual on-off switches, all such switches are turned on.

2.23. *Total harmonic distortion* (THD), expressed as a percent, is the root mean square (RMS) value of an AC signal after the fundamental component is removed and interharmonic components are ignored, divided by the RMS value of the fundamental component.

2.24. *Unit under test* (UUT) in this appendix refers to the combination of the battery charger and battery being tested.

3. Standard Test Conditions

3.1. General

The values that may be measured or calculated during the conduct of this test procedure have been summarized for easy reference in Table 3.1.

TABLE 3.1— LIST OF MEASURED OR CALCULATED VALUES

Name of measured or calculated value	Reference	Value
1. Duration of the charge and maintenance mode test	Section 5.2	
2. Battery Discharge Energy	Section 4.6	
3. Initial time and power (W) of the input current of connected battery	Section 5.8	
4. Active and Maintenance Mode Energy Consumption	Section 5.8	
5. Maintenance Mode Power	Section 5.9	
6. 24 Hour Energy Consumption	Section 5.10	
7. Standby Mode Power	Section 5.11	
8. Off Mode Power	Section 5.12	

3.2. Verifying Accuracy and Precision of Measuring Equipment

a. Measurements of active power of 0.5 W or greater shall be made with an uncertainty of ≤ 2 percent at the 95 percent confidence level. Measurements of active power of less than 0.5 W shall be made with an uncertainty of ≤ 0.01 W at the 95 percent confidence level. The power measurement instrument shall, as applicable, have a resolution of:

(1) 0.01 W or better for measurements up to 10 W;

(2) 0.1 W or better for measurements of 10 to 100 W; or

(3) 1 W or better for measurements over 100 W.

b. Measurements of energy (Wh) shall be made with an uncertainty of ≤ 2 percent at the 95 percent confidence level. Measurements of voltage and current shall be made with an uncertainty of ≤ 1 percent at the 95 percent confidence level. Measurements of temperature shall be made with an uncertainty of ≤ 2 °C at the 95 percent confidence level.

c. All equipment used to conduct the tests must be selected and calibrated to ensure that measurements will meet the above uncertainty requirements. For suggestions on measuring low power levels, see IEC 62301, (Reference for guidance only, see § 430.4) especially Section 5.3.2 and Annexes B and D.

3.3. Setting Up the Test Room

All tests, battery conditioning, and battery rest periods shall be carried out in a room with an air speed immediately surrounding the UUT of ≤ 0.5 m/s. The ambient temperature shall be maintained at 20 °C ± 5 °C throughout the test. There shall be no intentional cooling of the UUT such as by use of separately powered fans, air conditioners, or heat sinks. The UUT shall be conditioned, rested, and tested on a thermally non-conductive surface. When not undergoing active testing, batteries shall be stored at 20 °C ± 5 °C.

3.4. Verifying the UUT's Input Voltage and Input Frequency

a. If the UUT is intended for operation on AC line-voltage input in the United States, it shall be tested at 115 V at 60 Hz. If the UUT is intended for operation on AC line-voltage input but cannot be operated at 115 V at 60 Hz, it shall not be tested.

b. If a charger is powered by a low-voltage DC or AC input, and the manufacturer packages the charger with a wall adapter, sells, or recommends an optional wall adapter capable of providing that low voltage input, then the charger shall be tested using that wall adapter and the input reference source shall be 115 V at 60 Hz. If the wall adapter cannot be operated with AC input voltage at 115 V at 60 Hz, the charger shall not be tested.

c. If the UUT is designed for operation only on DC input voltage and the provisions of paragraph 3.4 (b) above do not apply, it shall be tested with one of the following input voltages: 5.0 V DC for products drawing power from a computer USB port or the midpoint of the rated input voltage range for all other products. The input voltage shall be within ± 1 percent of the above specified voltage.

d. If the input voltage is AC, the input frequency shall be within ± 1 percent of the specified frequency. The THD of the input voltage shall be ≤ 2 percent, up to and including the 13th harmonic. The crest factor of the input voltage shall be between 1.34 and 1.49.

e. If the input voltage is DC, the AC ripple voltage (RMS) shall be:

(1) ≤ 0.2 V for DC voltages up to 10 V; or

(2) ≤ 2 percent of the DC voltage for DC voltages over 10 V.

UNIT UNDER TEST SETUP REQUIREMENTS

4.1. General Setup

a. The battery charger system shall be prepared and set up in accordance with the manufacturer's instructions, except where those instructions conflict with the requirements of this test procedure. If no instructions are given, then factory or ''default'' settings shall be used, or where there are no indications of such settings, the UUT shall be tested in the condition as it would be supplied to an end user.

b. If the battery charger has user controls to select from two or more charge rates (such as regular or fast charge) or different charge currents, the test shall be conducted at the fastest charge rate that is recommended by the manufacturer for everyday use, or, failing any explicit recommendation, the factory-default charge rate. If the charger has user controls for selecting special charge cycles that are recommended only for occasional use to preserve battery health, such as equalization charge, removing memory, or battery conditioning, these modes are not required to be tested. The settings of the controls shall be listed in the report for each test.

4.2. Selection and Treatment of the Battery Charger

The UUT, including the battery charger and its associated battery, shall be new products of the type and condition that would be sold to a customer. If the battery is lead-acid chemistry and the battery is to be stored for more than 24 hours between its initial acquisition and testing, the battery shall be charged before such storage.

4.3. Selection of Batteries To Use for Testing

a. For chargers with integral batteries, the battery packaged with the charger shall be used for testing. For chargers with detachable batteries, the battery or batteries to be used for testing will vary depending on whether there are any batteries packaged with the battery charger.

(1) If batteries are packaged with the charger, batteries for testing shall be selected from the batteries packaged with the battery charger, according to the procedure in section 4.3.b.

(2) If no batteries are packaged with the charger, but the instructions specify or recommend batteries for use with the charger, batteries for testing shall be selected from those recommended or specified in the instructions, according to the procedure in section 4.3.b.

(3) If no batteries are packaged with the charger and the instructions do not specify or recommend batteries for use with the charger, batteries for testing shall be selected from any that are suitable for use with the charger, according to the procedure in section 4.3.b.

b. From the detachable batteries specified above, the technician shall use Table 4.1 to select the batteries to be used for testing depending on the type of charger being tested. Each row in the table represents a mutually exclusive charger type. The technician shall find the single applicable row for the UUT, and test according to those requirements.

c. A charger is considered as:

(1) Single-capacity if all associated batteries have the same rated charge capacity (see definition) and, if it is a batch charger, all configurations of the batteries have the same rated charge capacity.

(2) Multi-capacity if there are associated batteries or configurations of batteries that have different rated charge capacities.

d. The selected battery or batteries will be referred to as the ''test battery'' and will be used through the remainder of this test procedure.

TABLE 4.1—BATTERY SELECTION FOR TESTING

Type of charger			Tests to perform	
Multi-voltage	Multi-port	Multi-capacity	Number of tests	Battery selection (from all configurations of all associated batteries)
No	No	No	1	Any associated battery.
No	No	Yes	2	Lowest charge capacity battery. Highest charge capacity battery.
No	Yes	Yes or No	2	Use only one port and use the minimum number of batteries with the lowest rated charge capacity that the charger can charge. Use all ports and use the maximum number of identical batteries of the highest rated charge capacity the charger can accommodate.
Yes	No	No	2	Lowest voltage battery. Highest voltage battery.

TABLE 4.1—BATTERY SELECTION FOR TESTING—Continued

Type of charger			Tests to perform	
Multi-voltage	Multi-port	Multi-capacity	Number of tests	Battery selection (from all configurations of all associated batteries)
Yes	Yes to either or both		3	Of the batteries with the lowest voltage, use the one with the lowest charge capacity. Use only one port. Of the batteries with the highest voltage, use the one with the lowest charge capacity. Use only one port. Use all ports and use the battery or the configuration of batteries with the highest total rated energy capacity.

4.4. Limiting Other Non-Battery-Charger Functions

a. If the battery charger or product containing the battery charger does not have any additional functions unrelated to battery charging, this subsection may be skipped.

b. Any optional functions controlled by the user and not associated with the battery charging process (*e.g.*, the answering machine in a cordless telephone charging base) shall be switched off. If it is not possible to switch such functions off, they shall be set to their lowest power-consuming mode during the test.

c. If the battery charger takes any physically separate connectors or cables not required for battery charging but associated with its other functionality (such as phone lines, serial or USB connections, Ethernet, cable TV lines, *etc.*), these connectors or cables shall be left disconnected during the testing.

d. Any manual on-off switches specifically associated with the battery charging process shall be switched on for the duration of the charge, maintenance, and no-battery mode tests, and switched off for the off mode test.

4.5. Accessing the Battery for the Test

a. The technician may need to disassemble the end-use product or battery charger to gain access to the battery terminals for the Battery Discharge Energy Test in section 5.6. If the battery terminals are not clearly labeled, the technician shall use a voltmeter to identify the positive and negative terminals. These terminals will be the ones that give the largest voltage difference and are able to deliver significant current (0.2 C or 1/hr) into a load.

b. All conductors used for contacting the battery must be cleaned and burnished prior to connecting in order to decrease voltage drops and achieve consistent results.

c. Manufacturer's instructions for disassembly shall be followed, except those instructions that:

(1) Lead to any permanent alteration of the battery charger circuitry or function;

(2) Could alter the energy consumption of the battery charger compared to that experienced by a user during typical use, *e.g.*, due to changes in the airflow through the enclosure of the UUT; or

(3) Conflict requirements of this test procedure.

d. Care shall be taken by the technician during disassembly to follow appropriate safety precautions. If the functionality of the device or its safety features is compromised, the product shall be discarded after testing.

e. Some products may include protective circuitry between the battery cells and the remainder of the device. If the manufacturer provides a description for accessing the connections at the output of the protective circuitry, these connections shall be used to discharge the battery and measure the discharge energy. The energy consumed by the protective circuitry during discharge shall not be measured or credited as battery energy.

f. If the technician, despite diligent effort and use of the manufacturer's instructions, encounters any of the following conditions noted immediately below, the Battery Discharge Energy and the Charging and Maintenance Mode Energy shall be reported as ''Not Applicable'':

(1) Inability to access the battery terminals;

(2) Access to the battery terminals destroys charger functionality; or

(3) Inability to draw current from the test battery.

4.6. Determining Charge Capacity for Batteries With No Rating

If there is no rating for the battery charge capacity on the battery or in the instructions, then the technician shall determine a discharge current that meets the following requirements. The battery shall be fully charged and then discharged at this constant-current rate until it reaches the end-of-discharge voltage specified in Table 5.2. The discharge time must be not less than 4.5 hours nor more than 5 hours. In addition, the discharge test (Section 5.6) (which may not be starting with a fully-charged battery) shall reach the end-of-discharge voltage within 5 hours. The same discharge current shall be used for both the preparations step

(Section 5.4) and the discharge test (Section 5.6). The test report shall include the discharge current used and the resulting discharge times for both a fully-charged battery and for the discharge test.

For this section, the battery is considered as ''fully charged'' when either (a) it has been charged by the UUT until an indicator on the UUT shows that the charge is complete, or (b) it has been charged by a battery analyzer at a current not greater than the discharge current until the battery analyzer indicates that the battery is fully charged.

When there is no capacity rating, a suitable discharge current must generally be determined by trial and error. Since the conditioning step does not require constant-current discharges, the trials themselves may also be counted as part of battery conditioning.

5. TEST MEASUREMENT

The test sequence to measure the battery charger energy consumption is summarized in Table 5.1, and explained in detail below. Measurements shall be made under test conditions and with the equipment specified in Sections 3 and 4.

TABLE 5.1—TEST SEQUENCE

Step	Description	Data taken?	Equipment needed				
			Test battery	Charger	Battery analyzer or constant-current load	AC power meter	Thermometer (for flooded lead-acid battery chargers only)
1	Record general data on UUT; Section 5.1	Yes	X	X			
2	Determine test duration; Section 5.2	No					
3	Battery conditioning; Section 5.3	No	X	X	X		
4	Prepare battery for charge test; Section 5.4	No	X	X			
5	Battery rest period; Section 5.5	No	X				X
6	Conduct Charge Mode and Battery Maintenance Mode Test; Section 5.6.	Yes	X	X		X	
7	Battery Rest Period; Section 5.7	No	X				X
8	Battery Discharge Energy Test; Section 5.8	Yes	X		X		
9	Determining the Maintenance Mode Power; Section 5.9.	Yes	X	X		X	
10	Calculating the 24–Hour Energy Consumption; Section 5.10.	No					
11	Standby Mode Test; Section 5.11	Yes		X		X	
12	Off Mode Test; Section 5.12	Yes		X		X	

5.1. Recording General Data on the UUT

The technician shall record:

(1) The manufacturer and model of the battery charger;

(2) The presence and status of any additional functions unrelated to battery charging;

(3) The manufacturer, model, and number of batteries in the test battery;

(4) The rated battery voltage of the test battery;

(5) The rated charge capacity of the test battery; and

(6) The rated charge energy of the test battery.

(7) The settings of the controls, if battery charger has user controls to select from two or more charge rates

5.2. Determining the Duration of the Charge and Maintenance Mode Test

a. The charging and maintenance mode test, described in detail in section 5.8, shall be 24 hours in length or longer, as determined by the items below. Proceed in order until a test duration is determined.

(1) If the battery charger has an indicator to show that the battery is fully charged, that indicator shall be used as follows: If the indicator shows that the battery is charged after 19 hours of charging, the test shall be terminated at 24 hours. Conversely, if the full-charge indication is not yet present after 19 hours of charging, the test shall continue until 5 hours after the indication is present.

(2) If there is no indicator, but the manufacturer's instructions indicate that charging this battery or this capacity of battery should be complete within 19 hours, the test shall be for 24 hours. If the instructions indicate that charging may take longer than 19 hours, the test shall be run for the longest estimated charge time plus 5 hours.

(3) If there is no indicator and no time estimate in the instructions, but the charging current is stated on the charger or in the instructions, calculate the test duration as the longer of 24 hours or:

$$Duration = 1.4 \cdot \frac{RatedChargeCapacity\,(\mathrm{Ah})}{ChargeCurrent\,(\mathrm{A})} + 5\mathrm{h}$$

b. If none of the above applies, the duration of the test shall be 24 hours.

5.3. Battery Conditioning

a. No conditioning is to be done on lead-acid or lithium-ion batteries. The test technician shall proceed directly to battery preparation, section 5.4, when testing chargers for these batteries.

b. Products with integral batteries will have to be disassembled per the instructions in section 4.5, and the battery disconnected from the charger for discharging.

c. Batteries of other chemistries that have not been previously cycled are to be conditioned by performing two charges and two discharges, followed by a charge, as below. No data need be recorded during battery conditioning.

(1) The test battery shall be fully charged for the duration specified in section 5.2 or longer using the UUT.

(2) The test battery shall then be fully discharged using either:

(i) A battery analyzer at a rate not to exceed 1 C, until its average cell voltage under load reaches the end-of-discharge voltage specified in Table 5.2 for the relevant battery chemistry; or

(ii) The UUT, until the UUT ceases operation due to low battery voltage.

(3) The test battery shall again be fully charged as in step c.(1) of this section.

(4) The test battery shall again be fully discharged as per step c.(2) of this section.

(5) The test battery shall be again fully charged as in step c.(1) of this section.

d. Batteries of chemistries other than lead-acid or lithium-ion that are known to have been through at least two previous full charge/discharge cycles shall only be charged once per step c.(5), of this section.

5.4. Preparing the Battery for Charge Testing

Following any conditioning prior to beginning the battery charge test (section 5.6), the test battery shall be fully discharged for the duration specified in section 5.2 or longer using a battery analyzer.

5.5. Resting the Battery

The test battery shall be rested between preparation and the battery charge test. The rest period shall be at least one hour and not exceed 24 hours. For batteries with flooded cells, the electrolyte temperature shall be less than 30 °C before charging, even if the rest period must be extended longer than 24 hours.

5.6. Testing Charge Mode and Battery Maintenance Mode

a. The Charge and Battery Maintenance Mode test measures the energy consumed during charge mode and some time spent in the maintenance mode of the UUT. Functions required for battery conditioning that happen only with some user-selected switch or other control shall not be included in this measurement. (The technician shall manually turn off any battery conditioning cycle or setting.) Regularly occurring battery conditioning or maintenance functions that are not controlled by the user will, by default, be incorporated into this measurement.

b. During the measurement period, input power values to the UUT shall be recorded at least once every minute.

(1) If possible, the technician shall set the data logging system to record the average power during the sample interval. The total energy is computed as the sum of power samples (in watts) multiplied by the sample interval (in hours).

(2) If this setting is not possible, then the power analyzer shall be set to integrate or accumulate the input power over the measurement period and this result shall be used as the total energy.

c. The technician shall follow these steps:

(1) Ensure that the user-controllable device functionality not associated with battery charging and any battery conditioning cycle or setting are turned off, as instructed in section 4.4;

(2) Ensure that the test battery used in this test has been conditioned, prepared, discharged, and rested as described in sections 5.3 through 5.7;

(3) Connect the data logging equipment to the battery charger;

(4) Record the start time of the measurement period, and begin logging the input power;

(5) Connect the test battery to the battery charger within 3 minutes of beginning logging. For integral battery products, connect the product to a cradle or wall adapter within 3 minutes of beginning logging;

(6) After the test battery is connected, record the initial time and power (W) of the input current to the UUT. These measurements shall be taken within the first 10 minutes of active charging;

(7) Record the input power for the duration of the ‘‘Charging and Maintenance Mode Test’’ period, as determined by section 5.2. The actual time that power is connected to the UUT shall be within ±5 minutes of the specified period; and

(8) Disconnect power to the UUT, terminate data logging, and record the final time.

5.7. Resting the Battery

The test battery shall be rested between charging and discharging. The rest period shall be at least 1 hour and not more than 4 hours, with an exception for flooded cells. For batteries with flooded cells, the electrolyte temperature shall be less than 30 °C before charging, even if the rest period must be extended beyond 4 hours.

5.8. Battery Discharge Energy Test

a. If multiple batteries were charged simultaneously, the discharge energy is the sum of the discharge energies of all the batteries.

(1) For a multi-port charger, batteries that were charged in separate ports shall be discharged independently.

(2) For a batch charger, batteries that were charged as a group may be discharged individually, as a group, or in sub-groups connected in series and/or parallel. The position of each battery with respect to the other batteries need not be maintained.

b. During discharge, the battery voltage and discharge current shall be sampled and recorded at least once per minute. The values recorded may be average or instantaneous values.

c. For this test, the technician shall follow these steps:

(1) Ensure that the test battery has been charged by the UUT and rested according to the procedures above.

(2) Set the battery analyzer for a constant discharge current of 0.2 °C and the end-of-discharge voltage in Table 5.2 for the relevant battery chemistry.

(3) Connect the test battery to the analyzer and begin recording the voltage, current, and wattage, if available from the battery analyzer. When the end-of-discharge voltage is reached or the UUT circuitry terminates the discharge, the test battery shall be returned to an open-circuit condition. If current continues to be drawn from the test battery after the end-of-discharge condition is first reached, this additional energy is not to be counted in the battery discharge energy.

d. If not available from the battery analyzer, the battery discharge energy (in watt-hours) is calculated by multiplying the voltage (in volts), current (in amperes), and sample period (in hours) for each sample, and then summing over all sample periods until the end-of-discharge voltage is reached.

5.9. Determining the Maintenance Mode Power

After the measurement period is complete, the technician shall determine the average maintenance mode power consumption by examining the power-versus-time data from the charge and maintenance test and:

(1) If the maintenance mode power is cyclic or shows periodic pulses, compute the average power over a time period that spans a whole number of cycles and includes at least the last 4 hours.

(2) Otherwise, calculate the average power value over the last 4 hours.

5.10. Determining the 24-Hour Energy Consumption

The accumulated energy or the average input power, integrated over the test period from the charge and maintenance mode test, shall be used to calculate 24-hour energy consumption.

TABLE 5.2—REQUIRED BATTERY DISCHARGE RATES AND END-OF-DISCHARGE BATTERY VOLTAGES

Battery chemistry	Discharge rate *C*	End-of-discharge voltage *volts per cell*
Valve-Regulated Lead Acid (VRLA)	0.2	1.75
Flooded Lead Acid	0.2	1.70
Nickel Cadmium (NiCd)	0.2	1.0
Nickel Metal Hydride (NiMH)	0.2	1.0
Lithium Ion (Li-Ion)	0.2	2.5
Lithium Polymer	0.2	2.5
Rechargeable Alkaline	0.2	0.9
Nanophosphate Lithium Ion	0.2	2.0
Silver Zinc	0.2	1.2

5.11. Standby Mode Energy Consumption Measurement

The standby mode measurement depends on the configuration of the battery charger, as follows.

a. Conduct a measurement of standby power consumption while the battery charger is connected to the power source. Disconnect the battery from the charger, allow the charger to operate for at least 30 minutes, and record the power (*i.e.*, watts) consumed as the time series integral of the power consumed over a 10-minute test period, divided by the period of measurement. If the battery charger has manual on-off switches, all must be turned on for the duration of the standby mode test.

b. Standby mode may also apply to products with integral batteries. If the product uses a cradle and/or adapter for power conversion and charging, then ''disconnecting the battery from the charger'' will require disconnection of the end-use product, which contains the batteries. The other enclosures of the battery charging system will remain connected to the main electricity supply, and standby mode power consumption will equal that of the cradle and/or adapter alone.

c. If the product is powered through a detachable AC power cord and contains integrated power conversion and charging circuitry, then only the cord will remain connected to mains, and standby mode power consumption will equal that of the AC power cord (*i.e.*, zero watts).

d. Finally, if the product contains integrated power conversion and charging circuitry but is powered through a non-detachable AC power cord or plug blades, then no part of the system will remain connected to mains, and standby mode measurement is not applicable.

5.12. Off Mode Energy Consumption Measurement

The off mode measurement depends on the configuration of the battery charger, as follows.

a. If the battery charger has manual on-off switches, record a measurement of off mode energy consumption while the battery charger is connected to the power source. Remove the battery from the charger, allow the charger to operate for at least 30 minutes, and record the power (*i.e.*, watts) consumed as the time series integral of the power consumed over a 10-minute test period, divided by the period of measurement, with all manual on-off switches turned off. If the battery charger does not have manual on-off switches, record that the off mode measurement is not applicable to this product.

b. Off mode may also apply to products with integral batteries. If the product uses a cradle and/or adapter for power conversion and charging, then "disconnecting the battery from the charger" will require disconnection of the end-use product, which contains the batteries. The other enclosures of the battery charging system will remain connected to the main electricity supply, and off mode power consumption will equal that of the cradle and/or adapter alone.

c. If the product is powered through a detachable AC power cord and contains integrated power conversion and charging circuitry, then only the cord will remain connected to mains, and off mode power consumption will equal that of the AC power cord (*i.e.*, zero watts).

d. Finally, if the product contains integrated power conversion and charging circuitry but is powered through a non-detachable AC power cord or plug blades, then no part of the system will remain connected to mains, and off mode measurement is not applicable.

[76 FR 31776, June 1, 2011]

APPENDIX Z TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF EXTERNAL POWER SUPPLIES

1. *Scope*: This appendix covers the test requirements used to measure energy consumption of external power supplies.

2. *Definitions*: The following definitions are for the purposes of understanding terminology associated with the test method for measuring external power supply energy consumption. For clarity on any other terminology used in the test method, please refer to IEC Standard 60050 or IEEE Standard 100. (Reference for guidance only, see § 430.4.)

a. *Active mode* means the mode of operation when the external power supply is connected to the main electricity supply and the output is (or "all outputs are" for a multiple-voltage external power supply) connected to a load (or "loads" for a multiple-voltage external power supply).

b. *Active mode efficiency* is the ratio, expressed as a percentage, of the total real output power produced by a power supply to the real input power required to produce it. (Reference for guidance only, see IEEE Standard 1515–2000, 4.3.1.1, § 430.4.)

c. *Active power (P)* (also *real power*) means the average power consumed by a unit. For a two terminal device with current and voltage waveforms i(t) and v(t) which are periodic with period T, the real or active power P is:

$$P = \frac{1}{T}\int_0^T v(t)i(t)dt$$

d. *Ambient temperature* means the temperature of the ambient air immediately surrounding the unit under test.

e. *Apparent power* (S) is the product of RMS voltage and RMS current (VA).

f. *Instantaneous power* means the product of the instantaneous voltage and instantaneous current at a port (the terminal pair of a load).

g. *Manual on-off switch* is a switch activated by the user to control power reaching the device. This term does not apply to any mechanical, optical, or electronic switches that automatically disconnect mains power from the device when a load is disconnected from the device, or that control power to the load itself.

h. *Minimum output current* means the minimum current that must be drawn from an output bus for an external power supply to operate within its specifications.

i. *Multiple-voltage external power supply* means an external power supply that is designed to convert line voltage AC input into more than one simultaneous lower-voltage output.

j. *Nameplate input frequency* means the AC input frequency of the power supply as specified on the manufacturer's label on the power supply housing.

k. *Nameplate input voltage* means the AC input voltage of the power supply as specified on the manufacturer's label on the power supply housing.

l. *Nameplate output current* means the current output of the power supply as specified on the manufacturer's label on the power supply housing (either DC or AC) or, if absent from the housing, as provided by the manufacturer.

m. *Nameplate output power* means the power output of the power supply as specified on the manufacturer's label on the power supply housing or, if absent from the housing, as specified in documentation provided by the manufacturer.

n. *Nameplate output voltage* means the voltage output of the power supply as specified on the manufacturer's label on the power supply housing (either DC or AC).

o. *No-load mode* means the mode of operation when an external power supply is connected to the main electricity supply and the output is (or ''all outputs are'' for a multiple-voltage external power supply) not connected to a load (or ''loads'' for a multiple-voltage external power supply).

p. *Off mode* is the condition, applicable only to units with manual on-off switches, in which the external power supply is (1) connected to the main electricity supply; (2) the output is not connected to any load; and (3) all manual on-off switches are turned off.

q. *Output bus* means any of the outputs of the power supply to which loads can be connected and from which power can be drawn, as opposed to signal connections used for communication.

r. *Single-voltage external AC–AC power supply* means an external power supply that is designed to convert line voltage AC input into lower voltage AC output and is able to convert to only one AC output voltage at a time.

s. *Single-voltage external AC–DC power supply* means an external power supply that is designed to convert line voltage AC input into lower-voltage DC output and is able to convert to only one DC output voltage at a time.

t. *Standby mode* means the condition in which the external power supply is in no-load mode and, for external power supplies with manual on-off switches, all such switches are turned on.

u. *Switch-selectable single voltage external power supply* means a single-voltage AC–AC or AC–DC power supply that allows users to choose from more than one output voltage.

v. *Total harmonic distortion*, expressed as a percentage, is the RMS value of an AC signal after the fundamental component is removed and interharmonic components are ignored, divided by the RMS value of the fundamental component. THD of current is defined as:

$$THD_I = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots\ldots I_n^2}}{I_1}$$

where I_n is the RMS value of the nth harmonic of the current signal.

w. *True power factor* (PF) is the ratio of the active power (P) consumed in watts to the apparent power (S), drawn in volt-amperes.

$$PF = \frac{P}{S}$$

This definition of power factor includes the effect of both distortion and displacement.

x. *Unit under test* is the external power supply being tested.

3. *Test Apparatus and General Instructions:*

(a) Single-Voltage External Power Supply. The test apparatus, standard testing conditions, and instructions for testing external power supplies shall conform to the requirements specified in section 4, ''General Conditions for Measurement,'' of the CEC's ''Test Method for Calculating the Energy Efficiency of Single-Voltage External AC–DC and AC–AC Power Supplies,'' August 11, 2004. The test voltage specified in section 4.d, ''Test Voltage,'' shall only be 115 volts, 60 Hz.

(b) Multiple-Voltage External Power Supply. Unless otherwise specified, measurements shall be made under test conditions and with equipment specified below.

(i) Verifying Accuracy and Precision of Measuring Equipment

(A) Measurements of power 0.5 W or greater shall be made with an uncertainty of ≤ 2 percent at the 95 percent confidence level. Measurements of power less than 0.5 W shall be made with an uncertainty of ≤ 0.01 W at the 95 percent confidence level. The power measurement instrument shall have a resolution of:

(1) 0.01 W or better for measurements up to 10 W;

(2) 0.1 W or better for measurements of 10 to 100 W; or

(3) 1 W or better for measurements over 100 W.

(B) Measurements of energy (Wh) shall be made with an uncertainty of ≤ 2 percent at the 95 percent confidence level. Measurements of voltage and current shall be made with an uncertainty of ≤ 1 percent at the 95 percent confidence level. Measurements of temperature shall be made with an uncertainty of ≤ 2 °C at the 95 percent confidence level.

(C) All equipment used to conduct the tests must be selected and calibrated to ensure that measurements will meet the above uncertainty requirements. For guidance on measuring low power levels, see IEC 62301, Section 5.3.2 and Annexes B and D (Reference for guidance only, see § 430.4).

(ii) Setting Up the Test Room

All tests shall be carried out in a room with an air speed immediately surrounding the UUT of ≤ 0.5 m/s. The ambient temperature shall be maintained at 20 °C ± 5 °C throughout the test. There shall be no intentional cooling of the UUT such as by use of separately powered fans, air conditioners, or heat sinks. The UUT shall be conditioned, rested, and tested on a thermally non-conductive surface. A readily available material such as Styrofoam will be sufficient.

(iii) Verifying the UUT's Input Voltage and Input Frequency

(A) If the UUT is intended for operation on AC line-voltage input in the United States, it shall be tested at 115 V at 60 Hz. If the UUT is intended for operation on AC line-voltage input but cannot be operated at 115 V at 60 Hz, it shall not be tested. The input voltage shall be within ± 1 percent of the above specified voltage.

(B) If the input voltage is AC, the input frequency shall be within ± 1 percent of the specified frequency. The THD of the input voltage shall be ≤ 2 percent, up to and including the 13th harmonic. The crest factor of the input voltage shall be between 1.34 and 1.49.

4. *Test Measurement:*

(a) Single-Voltage External Power Supply

(i) Standby Mode and Active Mode Measurement—The measurement of standby mode (also no-load mode) energy consumption and active mode efficiency shall conform to the requirements specified in section 5, ''Measurement Approach'' of the CEC's ''Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc and Ac-Ac Power Supplies,'' August 11, 2004, (incorporated by reference, see § 430.3). Switch-selectable single-voltage external power supplies shall be tested twice—once at the highest nameplate output voltage and once at the lowest.

(A) If the product has more than two output wires, including those that are necessary for controlling the product, the manufacturer shall supply a connection diagram or test fixture that will allow the testing laboratory to put the unit under test into active mode.

(B) For those external power supplies that cannot sustain output at 100 percent loading condition, this efficiency metric shall not be included. For these external power supplies, the average efficiency is the average of the efficiencies measured at 25 percent, 50 percent, and 75 percent of maximum load.

(C) In the case where the external power supply lists both an instantaneous and continuous output current, it shall be tested at the continuous condition only.

(ii) Off-Mode Measurement—If the external power supply unit under test incorporates manual on-off switches, the unit under test shall be placed in off mode, and its power consumption in off mode measured and recorded. The measurement of the off mode energy consumption shall conform to the requirements specified in section 5, ''Measurement Approach,'' of the CEC's ''Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc and Ac-Ac Power Supplies,'' August 11, 2004 (incorporated by reference, see § 430.3), with two exceptions. In section 5.a, ''Preparing UUT [Unit Under Test] for Test,'' all manual on-off switches shall be placed in the ''off'' position for the measurement. In section 5.d, ''Testing Sequence,'' the technician shall consider the UUT stable if, over 5 minutes with samples taken at least once every second, the AC input power does not drift from the maximum value observed by more than 1 percent or 50 milliwatts, whichever is greater. The only loading condition that will be measured for off mode is ''Load Condition 5'' in Table 1 of the CEC's test procedure. Switch-selectable single-voltage external power supplies shall have their off mode power consumption measured twice— once at the highest nameplate output voltage and once at the lowest.

(b) Multiple-Voltage External Power Supply—Power supplies must be tested with the output cord packaged with the unit for sale to the consumer, as it is considered part of the unit under test. There are two options for connecting metering equipment to the output of this type of power supply: cut the cord immediately adjacent to the output connector or attach leads and measure the efficiency from the output connector itself. If the power supply is attached directly to the product that it is powering, cut the cord immediately adjacent to the powered product and connect output measurement probes at that point. The tests should be conducted on the sets of output wires that constitute the output busses. If the product has additional wires, these should be left electrically disconnected unless they are necessary for controlling the product. In this case, the manufacturer shall supply a connection diagram or test fixture that will allow the testing laboratory to put the unit under test into active mode.

(i) Standby-Mode and Active-Mode Measurement—The measurement of the multiple-voltage external power supply standby mode (also no-load-mode) energy consumption and active-mode efficiency shall be as follows:

(A) Loading conditions and testing sequence. (1) If the unit under test has on-off switches, all switches shall be placed in the ''on'' position. Loading criteria for multiple-voltage external power supplies shall be based on nameplate output current and not on nameplate output power because output voltage might not remain constant.

(2) The unit under test shall operate at 100 percent of nameplate current output for at least 30 minutes immediately before conducting efficiency measurements.

(3) After this warm-up period, the technician shall monitor AC input power for a period of 5 minutes to assess the stability of the unit under test. If the power level does not drift by more than 1 percent from the maximum value observed, the unit under test can be considered stable and measurements can be recorded at the end of the 5-minute period. Measurements at subsequent loading conditions, listed in Table 1, can then be conducted under the same 5-minute stability guidelines. Only one warm-up period of 30 minutes is required for each unit under test at the beginning of the test procedure.

(4) If AC input power is not stable over a 5-minute period, the technician shall follow the guidelines established by IEC Standard 62301 for measuring average power or accumulated energy over time for both input and output. (Reference for guidance only, see §430.4).

(5) The unit under test shall be tested at the loading conditions listed in Table 1, derated per the proportional allocation method presented in the following section.

TABLE 1—LOADING CONDITIONS FOR UNIT UNDER TEST

Loading Condition 1	100% of Derated Nameplate Output Current ± 2%.
Loading Condition 2	75% of Derated Nameplate Output Current ± 2%.
Loading Condition 3	50% of Derated Nameplate Output Current ± 2%.
Loading Condition 4	25% of Derated Nameplate Output Current ± 2%.
Loading Condition 5	0%.

(6) Input and output power measurements shall be conducted in sequence from Loading Condition 1 to Loading Condition 4, as indicated in Table 1. For Loading Condition 5, the unit under test shall be placed in no-load mode, any additional signal connections to the unit under test shall be disconnected, and input power shall be measured.

(B) Proportional allocation method for loading multiple-voltage external power supplies. For power supplies with multiple voltage busses, defining consistent loading criteria is difficult because each bus has its own nameplate output current. The sum of the power dissipated by each bus loaded to its nameplate output current may exceed the overall nameplate output power of the power supply. The following proportional allocation method must be used to provide consistent loading conditions for multiple-voltage external power supplies. For additional explanation, please refer to section 6.1.1 of the California Energy Commission's ''Proposed Test Protocol for Calculating the Energy Efficiency of Internal Ac-Dc Power Supplies Revision 6.2,'' November 2007.

(1) Consider a multiple-voltage power supply with N output busses, and nameplate output voltages $V_{1,}$ * * *, V_N, corresponding output current ratings $I_{1,}$ * * *, I_N, and a nameplate output power P. Calculate the derating factor D by dividing the power supply nameplate output power P by the sum of the nameplate output powers of the individual output busses, equal to the product of bus nameplate output voltage and current I_iV_i, as follows:

$$D = \frac{P}{\sum_{i=1}^{N} V_i I_i},$$

(2) If $D \geq 1$, then loading every bus to its nameplate output current does not exceed the overall nameplate output power for the power supply. In this case, each output bus will simply be loaded to the percentages of its nameplate output current listed in Table 1. However, if $D < 1$, it is an indication that loading each bus to its nameplate output current will exceed the overall nameplate output power for the power supply. In this case, and at each loading condition, each output bus will be loaded to the appropriate percentage of its nameplate output current listed in Table 1, multiplied by the derating factor D.

(C) Minimum output current requirements. Depending on their application, some multiple-voltage power supplies may require a minimum output current for each output bus of the power supply for correct operation. In these cases, ensure that the load current for each output at Loading Condition 4 in Table 1 is greater than the minimum output current requirement. Thus, if the test method's calculated load current for a given voltage bus is smaller than the minimum output current requirement, the minimum output current must be used to load the bus. This load current shall be properly recorded in any test report.

(D) Test loads. Active loads such as electronic loads or passive loads such as rheostats used for efficiency testing of the unit under test shall be able to maintain the required current loading set point for each output voltage within an accuracy of ± 0.5 percent. If electronic load banks are used, their settings should be adjusted such that they provide a constant current load to the unit under test.

(E) Efficiency calculation. Efficiency shall be calculated by dividing the measured active output power of the unit under test at a given loading condition by the active AC input power measured at that loading condition. Efficiency shall be calculated at each Loading Condition (1, 2, 3, and 4, in Table 1) and be recorded separately.

(F) Power consumption calculation. Power consumption of the unit under test at Loading Conditions 1, 2, 3, and 4 is the difference between the active output power at that Loading Condition and the active AC input power at that Loading Condition. The power consumption of Loading Condition 5 (no-load) is equal to the AC active input power at that Loading Condition.

(ii) Off Mode Measurement—If the multiple-voltage external power supply unit under test incorporates any on-off switches, the unit under test shall be placed in off mode and its power consumption in off mode measured and recorded. The measurement of the off mode energy consumption shall conform to the requirements specified in paragraph (4)(b)(i) of this appendix. Note that the only loading condition that will be measured for off mode is ''Loading Condition 5'' in paragraph (A), ''Loading conditions and testing sequence'', except that all manual on-off switches shall be placed in the off position for the measurement.

[71 FR 71366, Dec. 8, 2006, as amended at 74 FR 12066, Mar. 23, 2009; 74 FR 13334, Mar. 27, 2009; 76 FR 31782, June 1, 2011]

Subpart C—Energy and Water Conservation Standards

§ 430.31 Purpose and scope.

This subpart contains energy conservation standards and water conservation standards (in the case of faucets, showerheads, water closets, and urinals) for classes of covered products that are required to be administered by the Department of Energy pursuant to the Energy Conservation Program for Consumer Products Other Than Automobiles under the Energy Policy and Conservation Act, as amended (42 U.S.C. 6291 *et seq.*). Basic models of covered products manufactured before the date on which an amended energy conservation standard or water conservation standard (in the case of faucets, showerheads, water closets, and urinals) becomes effective (or revisions of such models that are manufactured after such date and have the same energy efficiency, energy use characteristics, or water use characteristics (in the case of faucets, showerheads, water closets, and urinals), that comply with the energy conservation standard or water conservation standard (in the case of faucets, showerheads, water closets, and urinals) applicable to such covered products on the day before such date shall be deemed to comply with the amended energy conservation standard or water conservation standard (in the case of faucets, showerheads, water closets, and urinals).

[63 FR 13317, Mar. 18, 1998]

§ 430.32 Energy and water conservation standards and their effective dates.

The energy and water (in the case of faucets, showerheads, water closets, and urinals) conservation standards for the covered product classes are:

(a) *Refrigerators/refrigerator-freezers/freezers*. These standards do not apply to refrigerators and refrigerator-freezers with total refrigerated volume exceeding 39 cubic feet (1104 liters) or freezers with total refrigerated volume exceeding 30 cubic feet (850 liters). The energy standards as determined by the equations of the following table(s) shall be rounded off to the nearest kWh per year. If the equation calculation is halfway between the nearest two kWh per year values, the standard shall be rounded up to the higher of these values.

The following standards remain in effect from July 1, 2001 until September 14, 2014:

Product class	Energy standard equations for maximum energy use (kWh/yr)
1. Refrigerators and refrigerator-freezers with manual defrost.	8.82AV + 248.4 0.31av + 248.4
2. Refrigerator-freezers—partial automatic defrost.	8.82AV + 248.4 0.31av + 248.4
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerator—automatic defrost.	9.80AV + 276.0 0.35av + 276.0
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without through-the-door ice service.	4.91AV + 507.5 0.17av + 507.5
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without through-the-door ice service.	4.60AV + 459.0 0.16av + 459.0
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	10.20AV + 356.0 0.36av + 356.0
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	10.10AV + 406.0 0.36av + 406.0
8. Upright freezers with manual defrost ..	7.55AV + 258.3 0.27av + 258.3
9. Upright freezers with automatic defrost.	12.43AV + 326.1 0.44av + 326.1

Product class	Energy standard equations for maximum energy use (kWh/yr)
10. Chest freezers and all other freezers except compact freezers.	9.88AV + 143.7 0.35av + 143.7
11. Compact refrigerators and refrigerator-freezers with manual defrost.	10.70AV + 299.0 0.38av + 299.0
12. Compact refrigerator-freezer—partial automatic defrost.	7.00AV + 398.0 0.25av + 398.0
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer and compact all-refrigerator—automatic defrost.	12.70AV + 355.0 0.45av + 355.0
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	7.60AV + 501.0 0.27av + 501.0
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	13.10AV + 367.0 0.46av + 367.0
16. Compact upright freezers with manual defrost.	9.78AV + 250.8 0.35av + 250.8
17. Compact upright freezers with automatic defrost.	11.40AV + 391.0 0.40av + 391.0
18. Compact chest freezers	10.45AV + 152.0 0.37av + 152.0

AV: Adjusted Volume in ft^3; av: Adjusted Volume in liters (L).

The following standards apply to products manufactured starting on September 14, 2014:

Product class	Equations for maximum energy use (kWh/yr)	
	Based on AV (ft^3)	Based on av (L)
1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	7.99AV + 225.0	0.282av + 225.0
1A. All-refrigerators—manual defrost	6.79AV + 193.6	0.240av + 193.6
2. Refrigerator-freezers—partial automatic defrost	7.99AV + 225.0	0.282av + 225.0
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	8.07AV + 233.7	0.285av + 233.7
3–BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	9.15AV + 264.9	0.323av + 264.9
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	8.07AV + 317.7	0.285av + 317.7
3I–BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	9.15AV + 348.9	0.323av + 348.9
3A. All-refrigerators—automatic defrost	7.07AV + 201.6	0.250av + 201.6
3A–BI. Built-in All-refrigerators—automatic defrost	8.02AV + 228.5	0.283av + 228.5
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	8.51AV + 297.8	0.301av + 297.8
4–BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	10.22AV + 357.4	0.361av + 357.4
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	8.51AV + 381.8	0.301av + 381.8
4I–BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	10.22AV + 441.4	0.361av + 441.4
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	8.85AV + 317.0	0.312av + 317.0
5–BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	9.40AV + 336.9	0.332av + 336.9
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	8.85AV + 401.0	0.312av + 401.0
5I–BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	9.40AV + 420.9	0.332av + 420.9
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	9.25AV + 475.4	0.327av + 475.4
5A–BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	9.83AV + 499.9	0.347av + 499.9
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	8.40AV + 385.4	0.297av + 385.4
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	8.54AV + 432.8	0.302av + 432.8
7–BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	10.25AV + 502.6	0.362av + 502.6
8. Upright freezers with manual defrost	5.57AV + 193.7	0.197av + 193.7
9. Upright freezers with automatic defrost without an automatic icemaker.	8.62AV + 228.3	0.305av + 228.3
9I. Upright freezers with automatic defrost with an automatic icemaker	8.62AV + 312.3	0.305av + 312.3
9–BI. Built-In Upright freezers with automatic defrost without an automatic icemaker.	9.86AV + 260.9	0.348av + 260.9

Product class	Equations for maximum energy use (kWh/yr)	
	Based on AV (ft^3)	Based on av (L)
9I–BI. Built-in upright freezers with automatic defrost with an automatic icemaker.	9.86AV + 344.9	0.348av + 344.9
10. Chest freezers and all other freezers except compact freezers	7.29AV + 107.8	0.257av + 107.8
10A. Chest freezers with automatic defrost	10.24AV + 148.1	0.362av + 148.1
11. Compact refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	9.03AV + 252.3	0.319av + 252.3
11A.Compact all-refrigerators—manual defrost	7.84AV + 219.1	0.277av + 219.1
12. Compact refrigerator-freezers—partial automatic defrost	5.91AV + 335.8	0.209av + 335.8
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer.	11.80AV + 339.2	0.417av + 339.2
13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker.	11.80AV + 423.2	0.417av + 423.2
13A. Compact all-refrigerators—automatic defrost	9.17AV + 259.3	0.324av + 259.3
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	6.82AV + 456.9	0.241av + 456.9
14I. Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker.	6.82AV + 540.9	0.241av + 540.9
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	11.80AV + 339.2	0.417av + 339.2
15I. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker.	11.80AV + 423.2	0.417av + 423.2
16. Compact upright freezers with manual defrost	8.65AV + 225.7	0.306av + 225.7
17. Compact upright freezers with automatic defrost	10.17AV + 351.9	0.359av + 351.9
18. Compact chest freezers	9.25AV + 136.8	0.327av + 136.8

AV = Total adjusted volume, expressed in ft^3, as determined in appendices A and B of subpart B of this part.
av = Total adjusted volume, expressed in Liters.

(b) *Room air conditioners.*

Product class	Energy efficiency ratio, effective from Oct. 1, 2000 to May 31, 2014	Combined energy efficiency ratio, effective as of June 1, 2014
1. Without reverse cycle, with louvered sides, and less than 6,000 Btu/h	9.7	11.0
2. Without reverse cycle, with louvered sides, and 6,000 to 7,999 Btu/h	9.7	11.0
3. Without reverse cycle, with louvered sides, and 8,000 to 13,999 Btu/h	9.8	10.9
4. Without reverse cycle, with louvered sides, and 14,000 to 19,999 Btu/h	9.7	10.7
5a. Without reverse cycle, with louvered sides, and 20,000 to 24,999 Btu/h	8.5	9.4
5b. Without reverse cycle, with louvered sides, and 25,000 Btu/h or more		9.0
6. Without reverse cycle, without louvered sides, and less than 6,000 Btu/h	9.0	10.0
7. Without reverse cycle, without louvered sides, and 6,000 to 7,999 Btu/h	9.0	10.0
8a. Without reverse cycle, without louvered sides, and 8,000 to 10,999 Btu/h	8.5	9.6
8b. Without reverse cycle, without louvered sides, and 11,000 to 13,999 Btu/h		9.5
9. Without reverse cycle, without louvered sides, and 14,000 to 19,999 Btu/h	8.5	9.3
10. Without reverse cycle, without louvered sides, and 20,000 Btu/h or more	8.5	9.4
11. With reverse cycle, with louvered sides, and less than 20,000 Btu/h	9.0	9.8
12. With reverse cycle, without louvered sides, and less than 14,000 Btu/h	8.5	9.3
13. With reverse cycle, with louvered sides, and 20,000 Btu/h or more	8.5	9.3
14. With reverse cycle, without louvered sides, and 14,000 Btu/h or more	8.0	8.7
15. Casement-Only	8.7	9.5
16. Casement-Slider	9.5	10.4

(c) *Central air conditioners and heat pumps*. The energy conservation standards defined in terms of the heating seasonal performance factor are based on Region IV, the minimum standardized design heating requirement, and the sampling plan stated in § 430.24(m).

(1) Split system central air conditioners and central air conditioning heat pumps manufactured after January 1, 1992, and before January 23, 2006, and single package central air conditioners and central air conditioning heat pumps manufactured after January 1, 1993, and before January 23, 2006, shall have Seasonal Energy Efficiency Ratio and Heating Seasonal Performance Factor no less than:

Product class	Seasonal energy efficiency ratio	Heating seasonal performance factor
(i) Split systems	10.0	6.8
(ii) Single package systems	9.7	6.6

(2) Central air conditioners and central air conditioning heat pumps manufactured on or after January 23, 2006, and before January 1, 2015, shall have Seasonal Energy Efficiency Ratio and Heating Seasonal Performance Factor no less than:

Product class	Seasonal energy efficiency ratio (SEER)	Heating seasonal performance factor (HSPF)
(i) Split-system air conditioners	13	
(ii) Split-system heat pumps	13	7.7
(iii) Single-package air conditioners	13	
(iv) Single-package heat pumps	13	7.7
(v)(A) Through-the-wall air conditioners and heat pumps-split system [1]	10.9	7.1
(v)(B) Through-the-wall air conditioners and heat pumps-single package [1]	10.6	7.0
(vi) Small-duct, high-velocity systems	13	7.7
(vii)(A) Space-constrained products—air conditioners	12	
(vii)(B) Space-constrained products—heat pumps	12	7.4

[1] The "through-the-wall air conditioners and heat pump—split system" and "through-the-wall air conditioner and heat pump—single package" product classes only applied to products manufactured prior to January 23, 2010. Products manufactured as of that date must be assigned to one of the remaining product classes listed in this table. The product class assignment depends on the product's characteristics. Product class definitions can be found in 10 CFR 430.2 and 10 CFR part 430, subpart B, appendix M. DOE believes that most, if not all, of the historically-characterized "through-the-wall" products will be assigned to one of the space-constrained product classes.

(3) Central air conditioners and central air conditioning heat pumps manufactured on or after January 1, 2015, shall have a Seasonal Energy Efficiency Ratio and Heating Seasonal Performance Factor not less than:

Product class [1]	Seasonal energy efficiency ratio (SEER)	Heating seasonal performance factor (HSPF)
(i) Split-system air conditioners	13	
(ii) Split-system heat pumps	14	8.2
(iii) Single-package air conditioners	14	
(iv) Single-package heat pumps	14	8.0
(v) Small-duct, high-velocity systems	13	7.7
(vi)(A) Space-constrained products—air conditioners	12	
(vi)(B) Space-constrained products—heat pumps	12	7.4

[1] The "through-the-wall air conditioners and heat pump—split system" and "through-the-wall air conditioner and heat pump—single package" product classes only applied to products manufactured prior to January 23, 2010. Products manufactured as of that date must be assigned to one of the remaining product classes listed in this table. The product class assignment depends on the product's characteristics. Product class definitions can be found in 10 CFR 430.2 and 10 CFR part 430, subpart B, appendix M. DOE believes that most, if not all, of the historically-characterized "through-the-wall" products will be assigned to one of the space-constrained product classes.

(4) In addition to meeting the applicable requirements in paragraph (c)(3) of this section, products in product class (i) of that paragraph (*i.e.*, split-system air conditioners) that are manufactured on or after January 1, 2015, and installed in the States of Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, or Virginia, or in the District of Columbia, shall have a Seasonal Energy Efficiency Ratio not less than 14.

(5) In addition to meeting the applicable requirements in paragraphs (c)(3) of this section, products in product classes (i) and (iii) of paragraph (c)(3) (*i.e.*, split-system air conditioners and single-package air conditioners) that are manufactured on or after January 1, 2015, and installed in the States of Arizona, California, Nevada, or New Mexico shall have a Seasonal Energy Efficiency Ratio not less than 14 and have an Energy Efficiency Ratio (at a standard rating of 95 °F dry bulb outdoor temperature) not less than the following:

Product class	Energy efficiency ratio (EER)
(i) Split-system rated cooling capacity less than 45,000 Btu/hr	12.2
(ii) Split-system rated cooling capacity equal to or greater than 45,000 Btu/hr	11.7
(iii) Single-package systems	11.0

(6) Central air conditioners and central air conditioning heat pumps manufactured on or after January 1, 2015, shall have an average off mode electrical power consumption not more than the following:

Product class	Average off mode power consumption $P_{W,OFF}$ (watts)
(i) Split-system air conditioners	30
(ii) Split-system heat pumps	33
(iii) Single-package air conditioners	30
(iv) Single-package heat pumps	33
(v) Small-duct, high-velocity systems	30
(vi) Space-constrained air conditioners	30
(vii) Space-constrained heat pumps	33

(d) *Water heaters*. The energy factor of water heaters shall not be less than the following for products manufactured on or after the indicated dates.

Product class	Energy factor as of January 20, 2004	Energy factor as of April 16, 2015
Gas-fired Water Heater	0.67 − (0.0019 × Rated Storage Volume in gallons).	For tanks with a Rated Storage Volume at or below 55 gallons: EF = 0.675 − (0.0015 × Rated Storage Volume in gallons). For tanks with a Rated Storage Volume above 55 gallons: EF = 0.8012 − (0.00078 × Rated Storage Volume in gallons).
Oil-fired Water Heater	0.59 − (0.0019 × Rated Storage Volume in gallons).	EF = 0.68 − (0.0019 × Rated Storage Volume in gallons).
Electric Water Heater	0.97 − (0.00132 × Rated Storage Volume in gallons).	For tanks with a Rated Storage Volume at or below 55 gallons: EF = 0.960 − (0.0003 × Rated Storage Volume in gallons). For tanks with a Rated Storage Volume above 55 gallons: EF = 2.057 − (0.00113 × Rated Storage Volume in gallons).
Tabletop Water Heater	0.93 − (0.00132 × Rated Storage Volume in gallons).	EF = 0.93 − (0.00132 × Rated Storage Volume in gallons).
Instantaneous Gas-fired Water Heater.	0.62 − (0.0019 × Rated Storage Volume in gallons).	EF = 0.82 − (0.0019 × Rated Storage Volume in gallons).
Instantaneous Electric Water Heater.	0.93 − (0.00132 × Rated Storage Volume in gallons).	EF = 0.93 − (0.00132 × Rated Storage Volume in gallons).

Note: The Rated Storage Volume equals the water storage capacity of a water heater, in gallons, as specified by the manufacturer.

(e) *Furnaces and boilers*. (1) *Furnaces*. (i) The Annual Fuel Utilization Efficiency (AFUE) of residential furnaces shall not be less than the following for non-weatherized furnaces manufactured before May 1, 2013, and weatherized furnaces manufactured before January 1, 2015:

Product class	AFUE (percent) [1]
(A) Furnaces (excluding classes noted below)	78
(B) Mobile Home furnaces	75
(C) Small furnaces (other than those designed solely for installation in mobile homes) having an input rate of less than 45,000 Btu/hr.	
(1) Weatherized (outdoor)	78
(2) Non-weatherized (indoor)	78

[1] Annual Fuel Utilization Efficiency, as determined in § 430.23(n)(2) of this part.

(ii) The AFUE of residential non-weatherized furnaces manufactured on or after May 1, 2013, and weatherized gas and oil-fired furnaces manufactured on or after January 1, 2015 shall be not less than the following:

Product class	AFUE (percent) [1]
(A) Non-weatherized gas furnaces (not including mobile home furnaces)	80
(B) Mobile Home gas furnaces	80
(C) Non-weatherized oil-fired furnaces (not including mobile home furnaces)	83
(D) Mobile Home oil-fired furnaces	75
(E) Weatherized gas furnaces	81
(F) Weatherized oil-fired furnaces	78
(G) Electric furnaces	78

[1] Annual Fuel Utilization Efficiency, as determined in § 430.23(n)(2) of this part.

(iii) In addition to meeting the applicable requirements in paragraph (e)(1)(ii) of this section, products in product classes (A) and (B) of that paragraph (*i.e.*, residential non-weatherized gas furnaces (including mobile home furnaces)) that are manufactured on or after May 1, 2013, and installed in the States of Alaska, Colorado, Connecticut, Idaho, Illinois, Indiana, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Washington, West Virginia, Wisconsin, and Wyoming, shall have an AFUE not less than 90 percent.

(iv) Furnaces manufactured on or after May 1, 2013, shall have an electrical standby mode power consumption ($P_{W,SB}$) and electrical off mode power consumption ($P_{W,OFF}$) not more than the following:

Product class	Maximum standby mode electrical power consumption, $P_{W,SB}$ (watts)	Maximum off mode electrical power consumption, $P_{W,OFF}$(watts)
(A) Non-weatherized gas furnaces (including mobile home furnaces)	10	10
(B) Non-weatherized oil-fired furnaces (including mobile home furnaces)	11	11
(C) Electric furnaces	10	10

(2) *Boilers*. (i) The AFUE of residential boilers manufactured before September 1, 2012, shall not be less than the following:

Product class	AFUE [1] (percent)
(A) Boilers (excluding gas steam)	80
(B) Gas steam boilers	75

[1] Annual Fuel Utilization Efficiency, as determined in § 430.22(n)(2) of this part.

(ii) Except as provided in paragraph (e)(2)(iv) of this section, the AFUE of residential boilers, manufactured on or after September 1, 2012, shall not be less than the following and must comply with the design requirements as follows:

Product class	AFUE [1] (percent)	Design requirements
(A) Gas-fired hot water boiler.	82	Constant burning pilot not permitted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
(B) Gas-fired steam boiler.	80	Constant burning pilot not permitted.
(C) Oil-fired hot water boiler.	84	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
(D) Oil-fired steam boiler.	82	None.
(E) Electric hot water boiler.	None	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).

[1] Annual Fuel Utilization Efficiency, as determined in § 430.22(n)(2) of this part.

(iii) *Automatic means for adjusting water temperature*. (A) The automatic means for adjusting water temperature as required under paragraph (e)(2)(ii) of this section must automatically adjust the temperature of the water supplied by the boiler to ensure that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of water supplied.

(B) For boilers that fire at a single input rate, the automatic means for adjusting water temperature requirement may be satisfied by providing an automatic means that allows the burner or heating element to fire only when the means has determined that the inferred heat load cannot be met by the residual heat of the water in the system.

(C) When there is no inferred heat load with respect to a hot water boiler, the automatic means described in this paragraph shall limit the temperature of the water in the boiler to not more than 140 degrees Fahrenheit.

(D) A boiler for which an automatic means for adjusting water temperature is required shall be operable only when the automatic means is installed.

(iv) A boiler that is manufactured to operate without any need for electricity or any electric connection, electric gauges, electric pumps, electric wires, or electric devices is not required to meet the AFUE or design requirements applicable to the boiler requirements of paragraph (e)(2)(ii) of this section, but must meet the requirements of paragraph (e)(2)(i) of this section, as applicable.

(f) *Dishwashers*. (1) The energy factor of dishwashers manufactured on or after May 14, 1994, must not be less than:

Product class	Energy factor (cycles/kWh)
(i) Compact Dishwasher (capacity less than eight place settings plus six serving pieces as specified in ANSI/AHAM DW–1 [Incorporated by reference, see § 430.22] using the test load specified in section 2.7 of appendix C in subpart B)	0.62
(ii) Standard Dishwasher (capacity equal to or greater than eight place settings plus six serving pieces as specified in ANSI/AHAM DW–1 [Incorporated by Reference, see § 430.22] using the test load specified in section 2.7 of appendix C in subpart B)	0.46

(2) All dishwashers manufactured on or after January 1, 2010, shall meet the following standard—

(i) Standard size dishwashers shall not exceed 355 kwh/year and 6.5 gallons per cycle.

(ii) Compact size dishwashers shall not exceed 260 kwh/year and 4.5 gallons per cycle.

(g) *Clothes washers*. (1) Clothes washers manufactured before January 1, 2004, shall have an energy factor no less than:

Product Class	Energy factor (cu.ft./kWh/cycle)
i. Top-Loading, Compact (less than 1.6 ft.^{3} capacity).	0.9.
ii. Top-Loading, Standard (1.6 ft.^{3} or greater capacity).	1.18.
iii. Top-Loading, Semi-Automatic	[1] Not Applicable.
iv. Front-Loading	[1] Not Applicable.
v. Suds-saving	[1] Not Applicable.

[1] Must have an unheated rinse water option.

(2) Clothes washers manufactured on or after January 1, 2004, and before January 1, 2007, shall have a modified energy factor no less than:

Product Class	Modified energy factor (cu.ft./kWh/cycle)
i. Top-Loading, Compact (less than 1.6 ft.^{3} capacity).	0.65.
ii. Top-Loading, Standard (1.6 ft.^{3} or greater capacity).	1.04.
iii. Top-Loading, Semi-Automatic	[1] Not Applicable.
iv. Front-Loading	1.04.
v. Suds-saving	[1] Not Applicable.

[1] Must have an unheated rinse water option.

(3) Clothes washers manufactured on or after January 1, 2007, shall have a modified energy factor no less than:

Product Class	Modified energy factor (cu.ft./kWh/cycle)
i. Top-Loading, Compact (less than 1.6 ft.^{3} capacity).	0.65.
ii. Top-Loading, Standard (1.6 ft.^{3} or greater capacity).	1.26.
iii. Top-Loading, Semi-Automatic	[1] Not Applicable.
iv. Front-Loading	1.26.
v. Suds-saving	[1] Not Applicable.

[1] Must have an unheated rinse water option.

(4) All top-loading or front-loading standard-size residential clothes washers manufactured on or after January 1, 2011, shall meet the following standard—

(i) A Modified Energy Factor of at least 1.26; and

(ii) A water factor of not more than 9.5.

(h) *Clothes dryers.* (1) Gas clothes dryers manufactured after January 1, 1988 shall not be equipped with a constant burning pilot.

(2) Clothes dryers manufactured on or after May 14, 1994 and before January 1, 2015, shall have an energy factor no less than:

Product class	Energy factor (lbs/kWh)
i. Electric, Standard (4.4 ft^3 or greater capacity)	3.01
ii. Electric, Compact (120V) (less than 4.4 ft^3 capacity)	3.13
iii. Electric, Compact (240V) (less than 4.4 ft^3 capacity)	2.90
iv. Gas	2.67

(3) Clothes dryers manufactured on or after January 1, 2015, shall have a combined energy factor no less than:

Product class	Combined energy factor (lbs/kWh)
i. Vented Electric, Standard (4.4 ft^3 or greater capacity)	3.73
ii. Vented Electric, Compact (120V) (less than 4.4 ft^3 capacity)	3.61
iii. Vented Electric, Compact (240V) (less than 4.4 ft^3 capacity)	3.27
iv. Vented Gas	3.30
v. Ventless Electric, Compact (240V) (less than 4.4 ft^3 capacity)	2.55
vi. Ventless Electric, Combination Washer-Dryer	2.08

(i) *Direct heating equipment.* (1) Vented home heating equipment manufactured on or after January 1, 1990 and before April 16, 2013, shall have an annual fuel utilization efficiency no less than:

Product class	Annual fuel utilization efficiency, Jan. 1, 1990 (percent)
1. Gas wall fan type up to 42,000 Btu/h	73
2. Gas wall fan type over 42,000 Btu/h	74
3. Gas wall gravity type up to 10,000 Btu/h	59
4. Gas wall gravity type over 10,000 Btu/h up to 12, 000 Btu/h	60
5. Gas wall gravity type over 12,000 Btu/h up to 15,000 Btu/h	61
6. Gas wall gravity type over 15,000 Btu/h up to 19,000 Btu/h	62
7. Gas wall gravity type over 19,000 Btu/h and up to 27,000 Btu/h	63
8. Gas wall gravity type over 27,000 Btu/h and up to 46,000 Btu/h	64
9. Gas wall gravity type over 46,000 Btu/h	65
10. Gas floor up to 37,000 Btu/h	56
11. Gas floor over 37,000 Btu/h	57
12. Gas room up to 18,000 Btu/h	57
13. Gas room over 18,000 Btu/h up to 20,000 Btu/h	58
14. Gas room over 20,000 Btu/h up to 27,000 Btu/h	63
15. Gas room over 27,000 Btu/h up to 46,000 Btu/h	64
16. Gas room over 46,000 Btu/h	65

(2) Vented home heating equipment manufactured on or after April 16, 2013, shall have an annual fuel utilization efficiency no less than:

Product class	Annual fuel utilization efficiency, April 16, 2013 (percent)
1. Gas wall fan type up to 42,000 Btu/h	75
2. Gas wall fan type over 42,000 Btu/h	76
3. Gas wall gravity type up to 27,000 Btu/h	65
4. Gas wall gravity type over 27,000 Btu/h up to 46,000 Btu/h	66
5. Gas wall gravity type over 46,000 Btu/h	67
6. Gas floor up to 37,000 Btu/h	57
7. Gas floor over 37,000 Btu/h	58
8. Gas room up to 20,000 Btu/h	61
9. Gas room over 20,000 Btu/h up to 27,000 Btu/h	66
10. Gas room over 27,000 Btu/h up to 46,000 Btu/h	67
11. Gas room over 46,000 Btu/h	68
12. Gas hearth up to 20,000 Btu/h	61
13. Gas hearth over 20,000 Btu/h and up to 27,000 Btu/h	66
14. Gas hearth over 27,000 Btu/h and up to 46,000 Btu/h	67
15. Gas hearth over 46,000 Btu/h	68

(j) *Cooking Products.* (1) Gas cooking products with an electrical supply cord shall not be equipped with a constant burning pilot light. This standard is effective on January 1, 1990.

(2) Gas cooking products without an electrical supply cord shall not be equipped with a constant burning pilot light. This standard is effective on April 9, 2012.

(k) *Pool heaters.* (1) Gas-fired pool heaters manufactured on or after January 1, 1990 and before April 16, 2013, shall have a thermal efficiency not less than 78%.

(2) Gas-fired pool heaters manufactured on or after April 16, 2013, shall have a thermal efficiency not less than 82%.

(l) *Television sets.* [Reserved]

(m)(1) *Fluorescent lamp ballasts (other than specialty application mercury vapor lamp ballasts).* Except as provided in paragraphs (m)(2), (m)(3), (m)(4), (m)(5), (m)(6) and (m)(7) of this section, each fluorescent lamp ballast—

(i) (A) Manufactured on or after January 1, 1990;

(B) Sold by the manufacturer on or after April 1, 1990; or

(C) Incorporated into a luminaire by a luminaire manufacturer on or after April 1, 1991; and

(ii) Designed—

(A) To operate at nominal input voltages of 120 or 277 volts;

(B) To operate with an input current frequency of 60 Hertz; and

(C) For use in connection with an F40T12, F96T12, or F96T12HO lamps shall have a power factor of 0.90 or greater and shall have a ballast efficacy factor not less than the following:

Application for operation of	Ballast input voltage	Total nominal lamp watts	Ballast efficacy factor
One F40 T12 lamp	120	40	1.805
	277	40	1.805
Two F40 T12 lamps	120	80	1.060
	277	80	1.050
Two F96T12 lamps	120	150	0.570
	277	150	0.570
Two F96T12HO lamps	120	220	0.390
	277	220	0.390

(2) The standards described in paragraph (m)(1) of this section do not apply to—

(i) A ballast that is designed for dimming or for use in ambient temperatures of 0 °F or less, or

(ii) A ballast that has a power factor of less than 0.90 and is designed for use only in residential building applications.

(3) Except as provided in paragraph (m)(4) of this section, each fluorescent lamp ballast—

(i) (A) Manufactured on or after April 1, 2005;

(B) Sold by the manufacturer on or after July 1, 2005; or

(C) Incorporated into a luminaire by a luminaire manufacturer on or after April 1, 2006; and

(ii) Designed—

(A) To operate at nominal input voltages of 120 or 277 volts;

(B) To operate with an input current frequency of 60 Hertz; and

(C) For use in connection with an F40T12, F96T12, or F96T12HO lamps; shall have a power factor of 0.90 or greater and shall have a ballast efficacy factor not less than the following:

Application of operation of	Ballast input voltage	Total nominal lamp watts	Ballast efficacy factor
One F40 T12 lamp	120	40	2.29
	277	40	2.29
Two F40 T12 lamps	120	80	1.17
	277	80	1.17
Two F96T12 lamps	120	150	0.63
	277	150	0.63
Two F96T12HO lamps	120	220	0.39
	277	220	0.39

(4) (i) The standards described in paragraph (m)(3) do not apply to:

(A) A ballast that is designed for dimming to 50 percent or less of its maximum output;

(B) A ballast that is designed for use with two F96T12HO lamps at ambient temperatures of −20 °F or less and for use in an outdoor sign;

(C) A ballast that has a power factor of less than 0.90 and is designed and labeled for use only in residential building applications; or

(D) A replacement ballast as defined in paragraph (m)(4)(ii) of this section.

(ii) For purposes of this paragraph (m), a replacement ballast is defined as a ballast that:

(A) Is manufactured on or before June 30, 2010;

(B) Is designed for use to replace an existing ballast in a previously installed luminaire;

(C) Is marked "FOR REPLACEMENT USE ONLY";

(D) Is shipped by the manufacturer in packages containing not more than 10 ballasts;

(E) Has output leads that when fully extended are a total length that is less than the length of the lamp with which it is intended to be operated; and

(F) Meets or exceeds the ballast efficacy factor in the following table:

Application for operation of	Ballast input voltage	Total nominal lamp watts	Ballast efficacy factor
One F40 T12 lamp	120	40	1.805
	277	40	1.805
Two F40 T12 lamps	120	80	1.060
	277	80	1.050
Two F96T12 lamps	120	150	0.570
	277	150	0.570
Two F96T12HO lamps	120	220	0.390
	277	220	0.390

(5) Except as provided in paragraph (m)(7) of this section, each fluorescent lamp ballast (other than replacement ballasts defined in § 430.2)—

(i)(A) Manufactured on or after July 1, 2009;

(B) Sold by the manufacturer on or after October 1, 2009; or

(C) Incorporated into a luminaire by a luminaire manufacturer on or after July 1, 2010; and

(ii) Designed—

(A) To operate at nominal input voltages of 120 or 277 volts;

(B) To operate with an input current frequency of 60 Hertz; and

(C) For use in connection with F34T12 lamps, F96T12/ES lamps, or F96T12HO/ES lamps; shall have a power factor of 0.90 or greater and shall have a ballast efficacy factor of not less than the following:

Application for operation of	Ballast input voltage	Total nominal lamp watts	Ballast efficacy factor
One F34T12 lamp	120/277	34	2.61
Two F34T12 lamps	120/277	68	1.35
Two F96T12/ES lamps	120/277	120	0.77
Two F96T12HO/ES lamps	120/277	190	0.42

(6) The standards in paragraph (m)(5) shall apply to all ballasts covered by paragraph (m)(5)(ii), including replacement ballasts and ballasts described in paragraph (m)(7) of this section, that are manufactured on or after July 1, 2010, or sold by the manufacturer on or after October 1, 2010.

(7) The standards in paragraph (m)(5) do not apply to—

(i) A ballast that is designed for dimming to 50 percent or less of the maximum output of the ballast;

(ii) A ballast that is designed for use with 2 F96T12HO lamps at ambient temperatures of 20 degrees F or less and for use in an outdoor sign; or

(iii) A ballast that has a power factor of less than 0.90 and is designed and labeled for use only in residential applications.

(n) *General service fluorescent lamps and incandescent reflector lamps.* (1) Except as provided in paragraphs (n)(2) and (n)(3) of this section, each of the following general service fluorescent lamps manufactured after the effective dates specified in the table shall meet or exceed the following lamp efficacy and CRI standards:

Lamp type	Nominal lamp wattage	Minimum CRI	Minimum average lamp efficacy (lm/W)	Effective date
4-foot medium bipin	>35W	69	75.0	Nov. 1, 1995.
	≤35W	45	75.0	Nov. 1, 1995.
2-foot U-shaped	>35W	69	68.0	Nov. 1, 1995.
8-foot slimline	≤35W	45	64.0	Nov. 1, 1995.
	>65W	69	80.0	May 1, 1994.
	>65W	45	80.0	May 1, 1994.
8-foot high output	>100W	69	80.0	May 1, 1994.

Lamp type	Nominal lamp wattage	Minimum CRI	Minimum average lamp efficacy (lm/W)	Effective date
	≤100W	45	80.0	May 1, 1994.

(2) The standards described in paragraph (n)(1) of this section do not apply to:

(i) Any 4-foot medium bipin lamp or 2-foot U-shaped lamp with a rated wattage less than 28 watts;

(ii) Any 8-foot high output lamp not defined in ANSI C78.81 (incorporated by reference; see § 430.3) or related supplements, or not 0.800 nominal amperes; or

(iii) Any 8-foot slimline lamp not defined in ANSI C78.3 (incorporated by reference; see § 430.3).

(3) Each of the following general service fluorescent lamps manufactured after July 14, 2012, shall meet or exceed the following lamp efficacy standards shown in the table:

Lamp type	Correlated color temperature	Minimum average lamp efficacy (lm/W)
4-foot medium bipin	≤4,500K	89
	>4,500K and ≤7,000K	88
2-foot U-shaped	≤4,500K	84
	>4,500K and ≤7,000K	81
8-foot slimline	≤4,500K	97
	>4,500K and ≤7,000K	93
8-foot high output	≤4,500K	92
	>4,500K and ≤7,000K	88
4-foot miniature bipin standard output	≤4,500K	86
	>4,500K and ≤7,000K	81
4-foot miniature bipin high output	≤4,500K	76
	>4,500K and ≤7,000K	72

(4) Except as provided in paragraph (n)(5) of this section, each of the following incandescent reflector lamps manufactured after November 1, 1995, shall meet or exceed the lamp efficacy standards shown in the table:

Nominal lamp wattage	Minimum average lamp efficacy (lm/W)
40–50	10.5
51–66	11.0
67–85	12.5
86–115	14.0
116–155	14.5
156–205	15.0

(5) Each of the following incandescent reflector lamps manufactured after July 14, 2012, shall meet or exceed the lamp efficacy standards shown in the table:

Rated lamp wattage	Lamp spectrum	Lamp diameter (inches)	Rated voltage	Minimum average lamp efficacy (lm/W)
40–205	Standard Spectrum	>2.5	≥125V	$6.8*P^{0.27}$
			<125V	$5.9*P^{0.27}$
		≤2.5	≥125V	$5.7*P^{0.27}$
			<125V	$5.0*P^{0.27}$
40–205	Modified Spectrum	>2.5	≤125V	$5.8*P^{0.27}$
			<125V	$5.0*P^{0.27}$
		≤2.5	≥125V	$4.9*P^{0.27}$
			<125V	$4.2*P^{0.27}$

Note 1: P is equal to the rated lamp wattage, in watts.
Note 2: Standard Spectrum means any incandescent reflector lamp that does not meet the definition of modified spectrum in 430.2.

(6) (i)(A) Subject to the exclusions in paragraph (n)(6)(ii) of this section, the standards specified in this section shall apply to ER incandescent reflector lamps, BR incandescent reflector lamps, BPAR incandescent reflector lamps, and similar bulb shapes on and after January 1, 2008.

(B) Subject to the exclusions in paragraph (n)(6)(ii) of this section, the standards specified in this section shall apply to incandescent reflector lamps with a diameter of more than 2.25 inches, but not more than 2.75 inches, on and after June 15, 2008.

(ii) The standards specified in this section shall not apply to the following types of incandescent reflector lamps:

(A) Lamps rated at 50 watts or less that are ER30, BR30, BR40, or ER40 lamps;

(B) Lamps rated at 65 watts that are BR30, BR40, or ER40 lamps; or

(C) R20 incandescent reflector lamps rated 45 watts or less.

(o) *Faucets*. The maximum water use allowed for any of the following faucets manufactured after January 1, 1994, when measured at a flowing water pressure of 60 pounds per square inch (414 kilopascals), shall be as follows:

Faucet type	Maximum flow rate (gpm (L/min)) or (gal/cycle (L/cycle))
Lavatory faucets	2.2 gpm (8.3 L/min) [1,2]
Lavatory replacement aerators.	2.2 gpm (8.3 L/min)
Kitchen faucets	2.2 gpm (8.3 L/min)
Kitchen replacement aerators.	2.2 gpm (8.3 L/min)
Metering faucets	0.25 gal/cycle (0.95 L/cycle) [3,4]

NOTE:

[1] Sprayheads with independently-controlled orifices and manual controls.

The maximum flow rate of each orifice that manually turns on or off shall not exceed the maximum flow rate for a lavatory faucet.

[2] Sprayheads with collectively controlled orifices and manual controls.

The maximum flow rate of a sprayhead that manually turns on or off shall be the product of (a) the maximum flow rate for a lavatory faucet and (b) the number of component lavatories (rim space of the lavatory in inches (millimeters) divided by 20 inches (508 millimeters)).

[3] Sprayheads with independently controlled orifices and metered controls.

The maximum flow rate of each orifice that delivers a preset volume of water before gradually shutting itself off shall not exceed the maximum flow rate for a metering faucet.

[4] Sprayheads with collectively-controlled orifices and metered controls.

The maximum flow rate of a sprayhead that delivers a preset volume of water before gradually shutting itself off shall be the product of (a) the maximum flow rate for a metering faucet and (b) the number of component lavatories (rim space of the lavatory in inches (millimeters) divided by 20 inches (508 millimeters)).

(p) *Showerheads*. The maximum water use allowed for any showerheads manufactured after January 1, 1994, shall be 2.5 gallons per minute (9.5 liters per minute) when measured at a flowing pressure of 80 pounds per square inch gage (552 kilopascals). Any such showerhead shall also meet the requirements of ASME/ANSI Standard A112.18.1M–1996, 7.4.4(a).

(q) *Water closets*. (1) The maximum water use allowed in gallons per flush for any of the following water closets manufactured after January 1, 1994, shall be as follows:

Water closet type	Maximum flush rate (gpf (Lpf))
Gravity tank-type toilets	1.6 (6.0)
Flushometer tank toilets	1.6 (6.0)
Electromechanical hydraulic toilets	1.6 (6.0)
Blowout toilets	3.5 (13.2)

(2) The maximum water use allowed for flushometer valve toilets, other than blowout toilets, manufactured after January 1, 1997, shall be 1.6 gallons per flush (6.0 liters per flush).

(r) *Urinals*. The maximum water use allowed for any urinals manufactured after January 1, 1994, shall be 1.0 gallons per flush (3.8 liters per flush). The maximum water use allowed for a trough-type urinal shall be the product of:

(1) The maximum flow rate for a urinal and

(2) The length of the trough-type urinal in inches (millimeter) divided by 16 inches (406 millimeters).

(s) *Ceiling fans and ceiling fan light kits*. (1) All ceiling fans manufactured on or after January 1, 2007, shall have the following features:

(i) Fan speed controls separate from any lighting controls;

(ii) Adjustable speed controls (either more than 1 speed or variable speed);

(iii) The capability of reversible fan action, except for—

(A) Fans sold for industrial applications;

(B) Fans sold for outdoor applications; and

(C) Cases in which safety standards would be violated by the use of the reversible mode.

(2)(i) Ceiling fan light kits with medium screw base sockets manufactured on or after January 1, 2007, shall be packaged with screw-based lamps to fill all screw base sockets.

(ii) The screw-based lamps required under paragraph (2)(i) of this section shall—

(A) Meet the ENERGY STAR Program requirements for Compact Fluorescent Lamps, version 3; or

(B) Use light sources other than compact fluorescent lamps that have lumens per watt performance at least equivalent to comparable configured compact fluorescent lamps meeting the energy conservation standards described in paragraph (2)(ii)(A) of this section.

(3) Ceiling fan light kits with pin-based sockets for fluorescent lamps manufactured on or after January 1, 2007 shall—

(i) Meet the ENERGY STAR Program Requirements for Residential Light Fixtures version 4.0 issued by the Environmental Protection Agency; and

(ii) Shall be packaged to include the lamps described in paragraph (s)(3)(i) of this section with the ceiling fan light kits to fill all sockets.

(4) Ceiling fan light kits with socket types other than those covered in paragraphs (2) and (3) of this section, including candelabra screw base sockets, manufactured on or after January 1, 2009—

(i) Shall not be capable of operating with lamps that total more than 190 watts; and

(ii) Shall be packaged to include the lamps described in clause (i) with the ceiling fan light kits.

(t) *Torchieres*. A torchiere manufactured on or after January 1, 2006 shall:

(1) Consume not more than 190 watts of power; and

(2) Not be capable of operating with lamps that total more than 190 watts.

(u) *Medium Base Compact Fluorescent Lamps*. A bare lamp and covered lamp (no reflector) medium base compact fluorescent lamp manufactured on or after January 1, 2006, shall meet the following requirements:

Factor	Requirements
Lamp Power (Watts) & Configuration [1]	Minimum Efficacy: lumens/watt(Based upon initial lumen data). [2]
Bare Lamp:	
Lamp Power <15	45.0.
Lamp Power ≥15	60.0.
Covered Lamp (no reflector):	
Lamp Power <15	40.0.
15≥ Lamp Power <19	48.0.
19≥ Lamp Power <25	50.0
Lamp Power ≥25	55.0.
1,000-hour Lumen Maintenance	The average of at least 5 lamps must be a minimum 90.0% of initial (100-hour) lumen output @ 1,000 hours of rated life.
Lumen Maintenance	80.0% of initial (100-hour) rating at 40 percent of rated life (per ANSI C78.5 Clause 4.10).
Rapid Cycle Stress Test	Per ANSI C78.5 and IESNA LM–65 (clauses 2,3,5, and 6). *Exception:* Cycle times must be 5 minutes on, 5 minutes off. Lamp will be cycled once for every two hours of rated life. At least 5 lamps *must meet or exceed* the minimum number of cycles.
Average Rated Lamp Life	≥6,000 hours as declared by the manufacturer on packaging. At 80% of rated life, statistical methods may be used to confirm lifetime claims based on sampling performance.

[1] Take performance and electrical requirements at the end of the 100-hour aging period according to ANSI Standard C78.5. The lamp efficacy shall be the average of the lesser of the lumens per watt measured in the base up and/or other specified positions. Use wattages place on packaging to select proper specification efficacy in this table, not measured wattage. Labeled wattages are for reference only.

[2] Efficacies are based on measured values for lumens and wattages from pertinent test data. Wattages and lumens placed on packages may not be used in calculation and are not governed by this specification. For multi-level or dimmable systems, measurements shall be at the highest setting. Acceptable measurement error is ±3%.

(v) *Dehumidifiers*. (1)Dehumidifiers manufactured on or after October 1, 2007, shall have an energy factor that meets or exceeds the following values:

Product capacity (pints/day)	Minimum energy factor (liters/kWh)
25.00 or less	1.00
25.01–35.00	1.20
35.01–54.00	1.30
54.01–74.99	1.50

Product capacity (pints/day)	Minimum energy factor (liters/kWh)
75.00 or more	2.25

(2) Dehumidifiers manufactured on or after October 1, 2012, shall have an energy factor that meets or exceeds the following values:

Product capacity (pints/day)	Minimum energy factor (liters/kWh)
Up to 35.00	1.35
35.01–45.00	1.50
45.01–54.00	1.60
54.01–75.00	1.70
75.00 or more	2.5

(w) *Class A external power supplies.* (1)(i) Except as provided in paragraphs (w)(1)(ii) and (w)(1)(iii) of this section, all Class A external power supplies manufactured on or after July 1, 2008, shall meet the following standards:

(ii) A class A external power supply shall not be subject to the standards in paragraph w(1)(i) if the class A external power supply is—

(A) Manufactured during the period beginning on July 1, 2008, and ending on June 30, 2015, and

(B) Made available by the manufacturer as a service part or a spare part for an end-use product—

(*1*) That constitutes the primary load; and

(*2*) Was manufactured before July 1, 2008.

(3) The standards described in paragraph (w)(1)(i) shall not constitute an energy conservation standard for the separate end-use product to which the external power supply is connected.

(4) Any class A external power supply manufactured on or after July 1, 2008 shall be clearly and permanently marked in accordance with the External Power Supply International Efficiency Marking Protocol, as referenced in the 'Energy Star Program Requirements for Single Voltage External Ac–Dc and Ac–Ac Power Supplies,' (incorporated by reference; see § 430.3), published by the Environmental Protection Agency.

(iii) *Non-application of no-load mode requirements.* The no-load mode energy efficiency standards established in paragraph (w)(1)(i) of this section shall not apply to an external power supply manufactured before July 1, 2017, that—

(A) Is an AC-to-AC external power supply;

(B) Has a nameplate output of 20 watts or more;

(C) Is certified to the Secretary as being designed to be connected to a security or life safety alarm or surveillance system component; and

(D) On establishment within the External Power Supply International Efficiency Marking Protocol, as referenced in the ''Energy Star Program Requirements for Single Voltage External Ac-Dc and Ac-Ac Power Supplies'' (incorporated by reference, see § 430.3), published by the Environmental Protection Agency, of a distinguishing mark for products described in this clause, is permanently marked with the distinguishing mark.

(x) *General service incandescent lamps, intermediate base incandescent lamps and candelabra base incandescent lamps.* (1) The energy conservation standards in this paragraph apply to general service incandescent lamps:

(i) Intended for a general service or general illumination application (whether incandescent or not);

(ii) Has a medium screw base or any other screw base not defined in ANSI C81.61 (incorporated by reference; see § 430.3); and

(iii) Is capable of being operated at a voltage at least partially within the range of 110 to 130 volts.

(A) General service incandescent lamps manufactured after the effective dates specified in the tables below, except as described in paragraph (x)(1)(B) of this section, shall have a color rendering index greater than or equal to 80 and shall have rated wattage no greater than and rated lifetime no less than the values shown in the table below:

GENERAL SERVICE INCANDESCENT LAMPS

Rated lumen ranges	Maximum rate wattage	Minimum rate life-time	Effective date
1490–2600	72	1,000 hrs	1/1/2012
1050–1489	53	1,000 hrs	1/1/2013

GENERAL SERVICE INCANDESCENT LAMPS—Continued

Rated lumen ranges	Maximum rate wattage	Minimum rate life-time	Effective date
750–1049	43	1,000 hrs	1/1/2014
310–749	29	1,000 hrs	1/1/2014

(B) Modified spectrum general service incandescent lamps manufactured after the effective dates specified shall have a color rendering index greater than or equal to 75 and shall have a rated wattage no greater than and rated lifetime no less than the values shown in the table below:

MODIFIED SPECTRUM GENERAL SERVICE INCANDESCENT LAMPS

Rated lumen ranges	Maximum rate wattage	Minimum rate life-time	Effective date
1118–1950	72	1,000 hrs	1/1/2012
788–1117	53	1,000 hrs	1/1/2013
563–787	43	1,000 hrs	1/1/2014
232–562	29	1,000 hrs	1/1/2014

(2) Each candelabra base incandescent lamp shall not exceed 60 rated watts.

(3) Each intermediate base incandescent lamp shall not exceed 40 rated watts.

[54 FR 6077, Feb. 7, 1989]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting § 430.32, see the List of CFR Sections Affected, which appears in the Finding Aids section of the printed volume and at *www.fdsys.gov*.

EFFECTIVE DATE NOTE: At 76 FR 70628, Nov. 14, 2011, § 430.32 was amended by revising paragraph (m)(1) introductory text; and adding paragraphs (m)(8), (m)(9), and m(10), effective Jan. 13, 2012. For the convenience of the user, the added and revised text is set forth as follows:

§ 430.32 Energy and water conservation standards and their effective dates.

* * * * *

(m)(1) *Fluorescent lamp ballasts (other than specialty application mercury vapor lamp ballasts)*. Except as provided in paragraphs (m)(2), (m)(3), (m)(4), (m)(5), (m)(6), (m)(7), (m)(8), (m)(9), and (m)(10) of this section, each fluorescent lamp ballast—

* * * * *

(8) Except as provided in paragraph (m)(9) of this section, each fluorescent lamp ballast—

(i) Manufactured on or after November 14, 2014;

(ii) Designed—

(A) To operate at nominal input voltages at or between 120 and 277 volts;

(B) To operate with an input current frequency of 60 Hertz; and

(C) For use in connection with fluorescent lamps (as defined in § 430.2)

(iii) Shall have—

(A) A power factor of 0.9 or greater except for those ballasts defined in paragraph (m)(8)(iii)(B) of this section;

(B) A power factor of 0.5 or greater for residential ballasts, which are defined in (m)(8)(vi) of this section;

(C) A ballast luminous efficiency not less than the following:

BLE = A/(1+B*average total lamp arc power ∧ −C) Where A, B, and C are as follows:

Description	A	B	C
Instant start and rapid start ballasts (not classified as residential) that are designed to operate 4-foot medium bipin lamps. 2-foot U-shaped lamps. 8-foot slimline lamps.	0.993	0.27	0.25
Programmed start ballasts (not classified as residential) that are designed to operate 4-foot medium bipin lamps. 2-foot U-shaped lamps. 4-foot miniature bipin standard output lamps. 4-foot miniature bipin high output lamps.	0.993	0.51	0.37

BLE = A/(1+B*average total lamp arc power ∧ −C) Where A, B, and C are as follows:			
Description	A	B	C
Instant start and rapid start ballasts (not classified as sign ballasts) that are designed to operate 8-foot high output lamps.	0.993	0.38	0.25
Programmed start ballasts (not classified as sign ballasts) that are designed to operate 8-foot high output lamps.	0.973	0.70	0.37
Sign ballasts that operate 8-foot high output lamps	0.993	0.47	0.25
Instant start and rapid start residential ballasts that operate 4-foot medium bipin lamps. 2-foot U-shaped lamps. 8-foot slimline lamps.	0.993	0.41	0.25
Programmed start residential ballasts that are designed to operate 4-foot medium bipin lamps. 2-foot U-shaped lamps.	0.973	0.71	0.37

(iv) Instant start, rapid start, and programmed start are defined in appendix Q1 of subpart B of this part. Average total lamp arc power is as defined and measured in accordance with appendix Q1 of subpart B of this part.

(v) Sign ballasts have an Underwriters Laboratories Inc. Type 2 rating and are designed, labeled, and marketed for use in outdoor signs.

(vi) Residential ballasts meet FCC consumer limits as set forth in 47 CFR part 18 and are designed and labeled for use in residential applications.

(9) The standards described in paragraph (m)(8) of this section do not apply to:

(i) A ballast that is designed for dimming to 50 percent or less of the maximum output of the ballast except for those specified in m(10); and

(ii) A low frequency ballast (as defined in appendix Q1 to subpart of this part) that:

(A) Is designed to operate T8 diameter lamps;

(B) Is designed, labeled, and marketed for use in EMI-sensitive environments only;

(C) Is shipped by the manufacturer in packages containing 10 or fewer ballasts; and

(iii) A programmed start ballast that operates 4-foot medium bipin T8 lamps and delivers on average less than 140 milliamperes to each lamp.

(10) Each fluorescent lamp ballast—

(i) Manufactured on or after November 14, 2014;

(ii) Designed—

(A) To operate at nominal input voltages of 120 or 277 volts;

(B) To operate with an input current frequency of 60 Hertz; and

(C) For use in connection with fluorescent lamps (as defined in §430.2);

(D) For dimming to 50 percent or less of the maximum output of the ballast

(iii) Shall have—

(A) A power factor of 0.9 or greater except for those ballasts defined in paragraph (m)(8)(iii)(B) of this section;

(B) A power factor of 0.5 or greater for residential ballasts, which meet FCC Part B consumer limits and are designed and labeled for use only in residential applications;

(C) A ballast luminous efficiency of not less than the following:

Designed for the operation of	Ballast input voltage	Total nominal lamp watts	Ballast luminous efficiency	
			Low frequency ballasts	High frequency ballasts
One F34T12 lamp	120/277	34	0.777	0.778
Two F34T12 lamps	120/277	68	0.804	0.805
Two F96T12/ES lamps	120/277	120	0.876	0.884
Two F96T12HO/ES lamps	120/277	190	0.711	0.713

* * * * *

§430.33 Preemption of State regulations.

(a) Any State regulation providing for any energy conservation standard, or water conservation standard (in the case of faucets, showerheads, water closets, and urinals), or other requirement with respect to the energy efficiency, energy use, or water use (in the case of faucets, showerheads, water closets, or urinals) of a covered product that is not identical to a Federal standard in effect under this subpart is preempted by that standard, except as provided for in sections 325(i)(6)(A)(vi), 327(b) and (c) of the Act.

(b) No State regulation, or revision thereof, concerning the energy efficiency, energy use, or water use of the covered product shall be effective with respect to such covered product, unless the State regulation or revision in the case of any portion of any regulation that establishes requirements for general service incandescent lamps, intermediate base incandescent lamps, or candelabra base lamps, was enacted or adopted by the State of California or Nevada before December 4, 2007, except that—

(1) The regulation adopted by the California Energy Commission with an effective date of January 1, 2008, shall only be effective until the effective date of the Federal standard for the applicable lamp category under paragraphs (A), (B), and (C) of section 325(i)(1) of EPCA;

(2) The States of California and Nevada may, at any time, modify or adopt a State standard for general service lamps to conform with Federal standards with effective dates no earlier than 12 months prior to the Federal effective dates prescribed under paragraphs (A), (B), and (C) of section 325(i)(1) of EPCA, at which time any prior regulations adopted by the State of California or Nevada shall no longer be effective; and

(3) All other States may, at any time, modify or adopt a State standard for general service lamps to conform with Federal standards and effective dates.

[63 FR 13318, Mar. 18, 1998, as amended at 74 FR 12070, Mar. 23, 2009]

§ 430.34 Energy and water conservation standards amendments

The Department of Energy may not prescribe any amended standard which increases the maximum allowable energy use or, in the case of showerheads, faucets, water closets or urinals, the maximum allowable water use, or which decreases the minimum required energy efficiency of a covered product.

[67 FR 36406, May 23, 2002]

§ 430.35 Petitions with respect to general service lamps.

(a) Any person may petition the Secretary for an exemption for a type of general service lamp from the requirements of this subpart. The Secretary may grant an exemption only to the extent that the Secretary finds, after a hearing and opportunity for public comment, that it is not technically feasible to serve a specialized lighting application (such as a military, medical, public safety or certified historic lighting application) using a lamp that meets the requirements of this subpart. To grant an exemption for a product under this paragraph, the Secretary shall include, as an additional criterion, that the exempted product is unlikely to be used in a general service lighting application.

(b) Any person may petition the Secretary to establish standards for lamp shapes or bases that are excluded from the definition of general service lamps. The petition shall include evidence that the availability or sales of exempted lamps have increased significantly since December 19, 2007. The Secretary shall grant a petition if the Secretary finds that:

(1) The petition presents evidence that demonstrates that commercial availability or sales of exempted incandescent lamp types have increased significantly since December 19, 2007 and are being widely used in general lighting applications; and

(2) Significant energy savings could be achieved by covering exempted products, as determined by the Secretary based on sales data provided to the Secretary from manufacturers and importers.

[74 FR 12070, Mar. 23, 2009]

Appendix A to Subpart C of Part 430—Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products

1. Objectives

This appendix establishes procedures, interpretations and policies to guide the DOE in the consideration and promulgation of new or revised appliance efficiency standards under the Energy Policy and Conservation Act (EPCA). The Department's objectives in establishing these guidelines include:

(a) *Provide for early input from stakeholders.* The Department seeks to provide opportunities for public input early in the rulemaking process so that the initiation and direction of rulemakings is informed by comment from interested parties. Under the guidelines established by this appendix, DOE will seek early input from interested parties in setting rulemaking priorities and structuring the analyses for particular products. Interested parties will be invited to provide input for the selection of design options and will help DOE identify analysis, data, and modeling needs. DOE will gather input from interested parties through a variety of mechanisms, including public workshops.

(b) *Increase predictability of the rulemaking timetable.* The Department seeks to make informed, strategic decisions about how to deploy its resources on the range of possible standards development activities, and to announce these prioritization decisions so that all interested parties have a common expectation about the timing of different rulemaking activities. The guidelines in this appendix provide for setting priorities and timetables for standards development and test procedure modification and reflect these priorities in the Regulatory Agenda.

(c) *Increase use of outside technical expertise.* The Department seeks to expand its use of outside technical experts in evaluating product-specific engineering issues to ensure that decisions on technical issues are fully informed. The guidelines in this appendix provide for increased use of outside technical experts in developing, performing and reviewing the analyses. Draft analytical results will be distributed for peer and stakeholder review.

(d) *Eliminate problematic design options early in the process.* The Department seeks to eliminate from consideration, early in the process, any design options that present unacceptable problems with respect to manufacturability, consumer utility, or safety, so that the detailed analysis can focus only on viable design options. Under the guidelines in this appendix, DOE will eliminate from consideration design options if it concludes that manufacture, installation or service of the design will be impractical, or that the design option will adversely affect the utility of the product, or if the design has adverse safety or health impacts. This screening will be done at the outset of a rulemaking.

(e) *Fully consider non-regulatory approaches.* The Department seeks to understand the effects of market forces and voluntary programs on encouraging the purchase of energy efficient products so that the incremental impacts of a new or revised standard can be accurately assessed and the Department can make informed decisions about where standards and voluntary ''market pull'' programs can be used most effectively. Under the guidelines in this appendix, DOE will solicit information on the effectiveness of market forces and non-regulatory approaches for encouraging the purchase of energy efficient products, and will carefully consider this information in assessing the benefits of standards. In addition, DOE will continue to support voluntary efforts by manufacturers, retailers, utilities and others to increase product efficiency.

(f) *Conduct thorough analysis of impacts.* In addition to understanding the aggregate costs and benefits of standards, the Department seeks to understand the distribution of those costs and benefits among consumers, manufacturers and others, and the uncertainty associated with these analyses of costs and benefits, so that any adverse impacts on significant subgroups and uncertainty concerning any adverse impacts can be fully considered in selecting a standard. Under the guidelines in this appendix, the analyses will consider the variability of impacts on significant groups of manufacturers and consumers in addition to aggregate costs and benefits, report the range of uncertainty associated with these impacts, and take into account cumulative impacts of regulation on manufacturers.

(g) *Use transparent and robust analytical methods.* The Department seeks to use qualitative and quantitative analytical methods that are fully documented for the public and that produce results that can be explained and reproduced, so that the analytical underpinnings for policy decisions on standards are as sound and well-accepted as possible. Under the guidelines in this appendix, DOE will solicit input from interested parties in identifying analysis, data, and modeling needs with respect to measurement of impacts on manufacturers and consumers.

(h) *Articulate policies to guide selection of standards.* The Department seeks to adopt policies elaborating on the statutory criteria for selecting standards, so that interested parties are aware of the policies that will guide these decisions. Under the guidelines in this appendix, policies for screening design options, selecting candidate standard levels, selecting a proposed standard level, and establishing the final standard are established.

(i) *Support efforts to build consensus on standards.* The Department seeks to encourage development of consensus proposals for new or revised standards because standards with such broad-based support are likely to balance effectively the economic, energy, and environmental interests affected by standards. Under the guidelines in this appendix, DOE will support the development and submission of consensus recommendations for standards by representative groups of interested parties to the fullest extent possible.

(j) *Reduce time and cost of developing standards.* The Department seeks to establish a clear protocol for initiating and conducting standards rulemakings in order to eliminate time-consuming and costly missteps. Under the guidelines in this appendix, increased and earlier involvement by interested parties and increased use of technical experts should minimize the need for re-analysis. This process should reduce the period between the publication of an Advance Notice of Proposed Rulemaking (ANOPR) and the publication of a final rule to not more than 18 months, and should decrease the government and private sector resources required to complete the standard development process.

2. Scope

(a) The procedures, interpretations and policies described in this appendix will be fully applicable to:

(1) Rulemakings concerning new or revised Federal energy conservation standards for consumer products initiated after August 14, 1996, and

(2) Rulemakings concerning new or revised Federal energy conservation standards for consumer products that have been initiated but for which a Notice of Proposed Rulemaking (NOPR) has not been published as of August 14, 1996.

(b) For rulemakings described in paragraph (a)(2) of this section, to the extent analytical work has already been done or public comment on an ANOPR has already been provided, such analyses and comment will be considered, as appropriate, in proceeding under the new process.

(c) With respect to incomplete rulemakings concerning new or revised Federal energy conservation standards for consumer products for which a NOPR was published prior to August 14, 1996, the Department will conduct a case-by-case review to decide whether any of the analytical or procedural steps already completed should be repeated. In any case, the approach described in this appendix will be used to the extent possible to conduct any analytical or procedural steps that have not been completed.

3. Setting Priorities for Rulemaking Activity

(a) *Priority-setting analysis and development of list of priorities.* At least once a year, the Department will prepare an analysis of each of the factors identified in paragraph (d) of this section based on existing literature, direct communications with interested parties and other experts, and other available information. The results of this analysis will be used to develop rulemaking priorities and proposed schedules for the development and issuance of all rulemakings. The DOE analysis, priorities and proposed rulemaking schedules will be documented and distributed for review and comment.

(b) *Public review and comment.* Each year, DOE will invite public input to review and comment on the priority analysis.

(c) *Issuance of final listing of rulemaking priorities.* Each fall, the Department will issue, simultaneously with the issuance of the Administration's Regulatory Agenda, a final set of rulemaking priorities, the accompanying analysis, and the schedules for all priority rulemakings that it anticipates within the next two years.

(d) *Factors for priority-setting.* The factors to be considered by DOE in developing priorities and establishing schedules for conducting rulemakings will include:

(1) Potential energy savings.

(2) Potential economic benefits.

(3) Potential environmental or energy security benefits.

(4) Applicable deadlines for rulemakings.

(5) Incremental DOE resources required to complete rulemaking process.

(6) Other relevant regulatory actions affecting products.

(7) Stakeholder recommendations.

(8) Evidence of energy efficiency gains in the market absent new or revised standards.

(9) Status of required changes to test procedures.

(10) Other relevant factors.

4. Process for Developing Efficiency Standards and Factors to be Considered

This section describes the process to be used in developing efficiency standards and the factors to be considered in the process. The policies of the Department to guide the selection of standards and the decisions preliminary thereto are described in section 5.

(a) *Identifying and screening design options.* Once the Department has initiated a rulemaking for a specific product but before publishing an ANOPR, DOE will identify the product categories and design options to be analyzed in detail, and identify those design options eliminated from further consideration. Interested parties will be consulted to identify key issues, develop a list of design options, and to help the Department identify the expertise necessary to conduct the analysis.

(1) *Identification of issues for analysis.* The Department, in consultation with interested parties, will identify issues that will be examined in the standards development process.

(2) *Identification of experts and other interested parties for peer review.* DOE, in consultation with interested parties, will identify a group of independent experts and other interested parties who can provide expert review of the results of the engineering analysis and the subsequent impact analysis.

(3) *Identification and screening of design options.* In consultation with interested parties, the Department will develop a list of design options for consideration. Initially, the candidate design options will encompass all those technologies considered to be technologically feasible. Following the development of this initial list of design options, DOE will review each design option based on the factors described in paragraph (a)(4) of this section and the policies stated in section 5(b). The reasons for eliminating any design option at this stage of the process will be fully documented and published as part of the ANOPR. The technologically feasible design options that are not eliminated in this screening will be considered further in the Engineering Analysis described in paragraph (b) of this section.

(4) *Factors for screening of design options.* The factors for screening design options include:

(i) Technological feasibility. Technologies incorporated in commercial products or in working prototypes will be considered technologically feasible.

(ii) Practicability to manufacture, install and service. If mass production of a technology in commercial products and reliable installation and servicing of the technology could be achieved on the scale necessary to serve the relevant market at the time of the effective date of the standard, then that technology will be considered practicable to manufacture, install and service.

(iii) Adverse Impacts on Product Utility or Product Availability.

(iv) Adverse Impacts on Health or Safety.

(5) *Selection of contractors.* Using the specifications of necessary contractor expertise developed in consultation with interested parties, DOE will select appropriate contractors, subcontractors, and as necessary, expert consultants to perform the engineering analysis and the impact analysis.

(b) *Engineering analysis of design options and selection of candidate standard levels.* After design options are identified and screened, DOE will perform the engineering analysis and the benefit/cost analysis and select the candidate standard levels based on these analyses. The results of the analyses will be published in a Technical Support Document (TSD) to accompany the ANOPR.

(1) *Identification of engineering analytical methods and tools.* DOE, in consultation with outside experts, will select the specific engineering analysis tools (or multiple tools, if necessary to address uncertainty) to be used in the analysis of the design options identified as a result of the screening analysis.

(2) *Engineering and life-cycle cost analysis of design options.* The DOE and its contractor will perform engineering and life-cycle cost analyses of the design options.

(3) *Review by expert group and stakeholders.* The results of the engineering and life-cycle cost analyses will be distributed for review by experts and interested parties. If appropriate, a public workshop will be conducted to review these results. The analyses will be revised as appropriate on the basis of this input.

(4) *New information relating to the factors used for screening design options.* If further information or analysis leads to a determination that a design option, or a combination of design options, has unacceptable impacts based on the policies stated in section 5(b), that design option or combination of design options will not be included in a candidate standard level.

(5) *Selection of candidate standard levels.* Based on the results of the engineering and life-cycle cost analysis of design options and the policies stated in section 5(c), DOE will select the candidate standard levels for further analysis.

(c) *Advance Notice of Proposed Rulemaking*—(1) *Documentation of decisions on candidate standard selection.* (i) If the screening analysis indicates that continued development of a standard is appropriate, the Department will publish an ANOPR in the FEDERAL REGISTER and will distribute a draft TSD containing the analyses performed to this point. The ANOPR will specify candidate standard levels but will not propose a particular standard. The ANOPR will also include the preliminary analysis of consumer life-cycle costs, national net present value, and energy impacts for the candidate standard levels based on the engineering analysis.

(ii) If the preliminary analysis indicates that no candidate standard level is likely to meet the criteria specified in law, that conclusion will be announced. In such cases, the Department may decide to proceed with a rulemaking that proposes not to adopt new or amended standards, or it may suspend the rulemaking and conclude that further action on such standards should be assigned a low priority under section 3.

(2) *Public comment and hearing.* There will be 75 days for public comment on the ANOPR with at least one public hearing or workshop.

(3) *Revisions based on comments.* Based on consideration of the comments received, any

necessary changes to the engineering analysis or the candidate standard levels will be made.

If major changes are required at this stage, interested parties and experts will be given an opportunity to review the revised analysis.

(d) *Analysis of impacts and selection of proposed standard level.* After the ANOPR, economic analyses of the impacts of the candidate standard levels will be conducted. The Department will propose updated standards based on the results of the impact analysis.

(1) *Identification of issues for analysis.* The Department, in consultation with interested parties, will identify issues that will be examined in the impacts analysis.

(2) *Identification of analytical methods and tools.* DOE, in consultation with outside experts, will select the specific economic analysis tools (or multiple tools if necessary to address uncertainty) to be used in the analysis of the candidate standard levels.

(3) *Analysis of impacts.* DOE will conduct the analysis of the impacts of candidate standard levels including analysis of the factors described in paragraphs (d)(7)(ii)–(viii) of this section.

(4) *Review by expert group and stakeholders.* The results of the analysis of impacts will be distributed for review by experts and interested parties. If appropriate, a public workshop will be conducted to review these results. The analysis will be revised as appropriate on the basis of this input.

(5) *Efforts to develop consensus among stakeholders.* If a representative group of interested parties undertakes to develop joint recommendations to the Department on standards, DOE will consider deferring its impact analysis until these discussions are completed or until participants in the efforts indicate that they are unable to reach a timely agreement.

(6) *Selection of proposed standard level based on analysis of impacts.* On the basis of the analysis of the factors described in paragraph (d)(7) of this section and the policies stated in section 5(e), DOE will select a proposed standard level.

(7) *Factors to be considered in selecting a proposed standard.* The factors to be considered in selection of a proposed standard include:

(i) Consensus stakeholder recommendations.

(ii) Impacts on manufacturers. The analysis of manufacturer impacts will include: Estimated impacts on cash flow; assessment of impacts on manufacturers of specific categories of products and small manufacturers; assessment of impacts on manufacturers of multiple product-specific Federal regulatory requirements, including efficiency standards for other products and regulations of other agencies; and impact on manufacturing capacity, plant closures, and loss of capital investment.

(iii) Impacts on consumers. The analysis of consumer impacts will include: Estimated impacts on consumers based on national average energy prices and energy usage; assessments of impacts on subgroups of consumers based on major regional differences in usage or energy prices and significant variations in installation costs or performance; sensitivity analyses using high and low discount rates and high and low energy price forecasts; consideration of changes to product utility and other impacts of likely concern to all or some consumers, based to the extent practicable on direct input from consumers; estimated life-cycle cost with sensitivity analysis; and consideration of the increased first cost to consumers and the time required for energy cost savings to pay back these first costs.

(iv) Impacts on competition.

(v) Impacts on utilities. The analysis of utility impacts will include estimated marginal impacts on electric and gas utility costs and revenues.

(vi) National energy, economic and employment impacts. The analysis of national energy, economic and employment impacts will include: Estimated energy savings by fuel type; estimated net present value of benefits to all consumers; and estimates of the direct and indirect impacts on employment by appliance manufacturers, relevant service industries, energy suppliers and the economy in general.

(vii) Impacts on the environment and energy security. The analysis of environmental and energy security impacts will include estimated impacts on emissions of carbon and relevant criteria pollutants, impacts on pollution control costs, and impacts on oil use.

(viii) Impacts of non-regulatory approaches. The analysis of energy savings and consumer impacts will incorporate an assessment of the impacts of market forces and existing voluntary programs in promoting product efficiency, usage and related characteristics in the absence of updated efficiency standards.

(ix) New information relating to the factors used for screening design options.

(e) *Notice of Proposed Rulemaking*—(1) *Documentation of decisions on proposed standard selection.* The Department will publish a NOPR in the FEDERAL REGISTER that proposes standard levels and explains the basis for the selection of those proposed levels, and will distribute a draft TSD documenting the analysis of impacts. As required by §325(p)(2) of EPCA, the NOPR also will describe the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible and, if the proposed standards would not achieve these levels, the reasons for proposing different standards.

(2) *Public comment and hearing.* There will be 75 days for public comment on the NOPR,

with at least one public hearing or workshop.

(3) *Revisions to impact analyses and selection of final standard.* Based on the public comments received and the policies stated in section 5(f), DOE will review the proposed standard and impact analyses, and make modifications as necessary. If major changes to the analyses are required at this stage, interested parties and experts will be given an opportunity to review the revised analyses.

(f) *Notice of Final Rulemaking.* The Department will publish a Notice of Final Rulemaking in the FEDERAL REGISTER that promulgates standard levels and explains the basis for the selection of those standards, accompanied by a final TSD.

5. Policies on Selection of Standards.

(a) *Purpose.* (1) Section 4 describes the process that will be used to consider new or revised energy efficiency standards and lists a number of factors and analyses that will be considered at specified points in the process. Department policies co12467ncerning the selection of new or revised standards, and decisions preliminary thereto, are described in this section.

These policies are intended to elaborate on the statutory criteria provided in section 325 of the EPCA, 42 U.S.C. 6295.

(2) The policies described below are intended to provide guidance for making the determinations required by EPCA. This statement of policy is not intended to preclude consideration of any information pertinent to the statutory criteria. The Department will consider all pertinent information in determining whether a new or revised standard is consistent with the statutory criteria. Moreover, the Department will not be guided by a policy in this section if, in the particular circumstances presented, such a policy would lead to a result inconsistent with the criteria in section 325 of EPCA.

(b) *Screening design options.* Section 4(a)(4) lists factors to be considered in screening design options. These factors will be considered as follows in determining whether a design option will receive any further consideration:

(1) *Technological feasibility.* Technologies that are not incorporated in commercial products or in working prototypes will not be considered further.

(2) *Practicability to manufacture, install and service.* If it is determined that mass production of a technology in commercial products and reliable installation and servicing of the technology could not be achieved on the scale necessary to serve the relevant market at the time of the effective date of the standard, then that technology will not be considered further.

(3) *Impacts on product utility to consumers.* If a technology is determined to have significant adverse impact on the utility of the product to significant subgroups of consumers, or result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the U.S. at the time, it will not be considered further.

(4) *Safety of technologies.* If it is determined that a technology will have significant adverse impacts on health or safety, it will not be considered further.

(c) *Identification of candidate standard levels.* Based on the results of the engineering and cost and benefit analyses of design options, DOE will identify the candidate standard levels for further analysis. Candidate standard levels will be selected as follows:

(1) *Costs and savings of design options.* Design options which have payback periods that exceed the average life of the product or which cause life-cycle cost increases relative to the base case, using typical fuel costs, usage and discount rates, will not be used as the basis for candidate standard levels.

(2) *Further information on factors used for screening design options.* If further information or analysis leads to a determination that a design option, or a combination of design options, has unacceptable impacts under the policies stated in paragraph (b) of this section, that design option or combination of design options will not be included in a candidate standard level.

(3) *Selection of candidate standard levels.* Candidate standard levels, which will be identified in the ANOPR and on which impact analyses will be conducted, will be based on the remaining design options.

(i) The range of candidate standard levels will typically include:

(A) The most energy efficient combination of design options;

(B) The combination of design options with the lowest life-cycle cost; and

(C) A combination of design options with a payback period of not more than three years.

(ii) Candidate standard levels that incorporate noteworthy technologies or fill in large gaps between efficiency levels of other candidate standard levels also may be selected.

(d) *Advance notice of proposed rulemaking.* New information provided in public comments on the ANOPR will be considered to determine whether any changes to the candidate standard levels are needed before proceeding to the analysis of impacts. This review, and any appropriate adjustments, will be based on the policies in paragraph (c) of this section.

(e) *Selection of proposed standard.* Based on the results of the analysis of impacts, DOE will select a standard level to be proposed for public comment in the NOPR. Section 4(d)(7) lists the factors to be considered in selecting a proposed standard level. Section

325(o)(2)(A) of EPCA provides that any new or revised standard must be designed to achieve the maximum improvement in energy efficiency that is determined to be technologically feasible and economically justified.

(1) *Statutory policies.* The fundamental policies concerning selection of standards are established in the EPCA, including the following:

(i) A candidate standard level will not be proposed or promulgated if the Department determines that it is not technologically feasible and economically justified. See EPCA section 325(o)(3)(B). A standard level is economically justified if the benefits exceed the burdens. See EPCA section 325(o)(2)(B)(i). A standard level is rebuttably presumed to be economically justified if the payback period is three years or less. See EPCA section 325(o)(2)(B)(iii).

(ii) If the Department determines that a standard level is likely to result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the U.S. at the time, that standard level will not be proposed. See EPCA section 325(o)(4).

(iii) If the Department determines that a standard level would not result in significant conservation of energy, that standard level will not be proposed. See EPCA section 325(o)(3)(B).

(2) *Selection of proposed standard on the basis of consensus stakeholder recommendations.* Development of consensus proposals for new or revised standards is an effective mechanism for balancing the economic, energy, and environmental interests affected by standards. Thus, notwithstanding any other policy on selection of proposed standards, a consensus recommendation on an updated efficiency level submitted by a group that represents all interested parties will be proposed by the Department if it is determined to meet the statutory criteria.

(3) *Considerations in assessing economic justification.*

(i) The following policies will guide the application of the economic justification criterion in selecting a proposed standard:

(A) If the Department determines that a candidate standard level would result in a negative return on investment for the industry, would significantly reduce the value of the industry, or would cause significant adverse impacts to a significant subgroup of manufacturers (including small manufacturing businesses), that standard level will be presumed not to be economically justified unless the Department determines that specifically identified expected benefits of the standard would outweigh this and any other expected adverse effects.

(B) If the Department determines that a candidate standard level would be the direct cause of plant closures, significant losses in domestic manufacturer employment, or significant losses of capital investment by domestic manufacturers, that standard level will be presumed not to be economically justified unless the Department determines that specifically identified expected benefits of the standard would outweigh this and any other expected adverse effects.

(C) If the Department determines that a candidate standard level would have a significant adverse impact on the environment or energy security, that standard level will be presumed not to be economically justified unless the Department determines that specifically identified expected benefits of the standard would outweigh this and any other expected adverse effects.

(D) If the Department determines that a candidate standard level would not result in significant energy conservation relative to non-regulatory approaches, that standard level will be presumed not to be economically justified unless the Department determines that other specifically identified expected benefits of the standard would outweigh the expected adverse effects.

(E) If the Department determines that a candidate standard level is not consistent with the policies relating to practicability to manufacture, consumer utility, or safety in paragraphs (b) (2), (3) and (4) of this section, that standard level will be presumed not to be economically justified unless the Department determines that specifically identified expected benefits of the standard would outweigh this and any other expected adverse effects.

(F) If the Department determines that a candidate standard level is not consistent with the policies relating to consumer costs in paragraph (c)(1) of this section, that standard level will be presumed not to be economically justified unless the Department determines that specifically identified expected benefits of the standard would outweigh this and any other expected adverse effects.

(G) If the Department determines that a candidate standard level will have significant adverse impacts on a significant subgroup of consumers (including low-income consumers), that standard level will be presumed not to be economically justified unless the Department determines that specifically identified expected benefits of the standard would outweigh this and any other expected adverse effects.

(H) If the Department or the Department of Justice determines that a candidate standard level would have significant anticompetitive effects, that standard level will be presumed not to be economically justified unless the Department determines that specifically identified expected benefits of the standard would outweigh this and any other expected adverse effects.

(ii) The basis for a determination that triggers any presumption in paragraph (e)(3)(i) of this section and the basis for a determination that an applicable presumption has been rebutted will be supported by substantial evidence in the record and the evidence and rationale for making these determinations will be explained in the NOPR.

(iii) If none of the policies in paragraph (e)(3)(i) of this section is found to be dispositive, the Department will determine whether the benefits of a candidate standard level exceed the burdens considering all the pertinent information in the record.

(f) *Selection of a final standard.* New information provided in the public comments on the NOPR and any analysis by the Department of Justice concerning impacts on competition of the proposed standard will be considered to determine whether any change to the proposed standard level is needed before proceeding to the final rule. The same policies used to select the proposed standard level, as described in section 5(e) above, will be used to guide the selection of the final standard level.

6. Effective Date of a Standard

The effective date for new or revised standards will be established so that the period between the publication of the final rule and the effective date is not less than any period between the dates for publication and effective date provided for in EPCA. The effective date of any revised standard will be established so that the period between the effective date of the prior standard and the effective date of such revised standard is not less than period between the two effective dates provided for in EPCA.

7. Test Procedures

(a) *Identifying the need to modify test procedures.* DOE, in consultation with interested parties, experts, and the National Institute of Standards and Technology, will attempt to identify any necessary modifications to established test procedures when initiating the standards development process.

(b) *Developing and proposing revised test procedures.* Needed modifications to test procedures will be identified in consultation with experts and interested parties early in the screening stage of the standards development process. Any necessary modifications will be proposed before issuance of an ANOPR in the standards development process.

(c) *Issuing final test procedure modification.* Final, modified test procedures will be issued prior to the NOPR on proposed standards.

(d) *Effective date of modified test procedures.* If required only for the evaluation and issuance of updated efficiency standards, modified test procedures typically will not go into effect until the effective date of updated standards.

8. Joint Stakeholder Recommendations

(a) *Joint recommendations.* Consensus recommendations, and supporting analyses, submitted by a representative group of interested parties will be given substantial weight by DOE in the development of a proposed rule. See section 5(e)(2). If the supporting analyses provided by the group addresses all of the statutory criteria and uses valid economic assumptions and analytical methods, DOE expects to use this supporting analyses as the basis of a proposed rule. The proposed rule will explain any deviations from the consensus recommendations from interested parties.

(b) *Breadth of participation.* Joint recommendations will be of most value to the Department if the participants are reasonably representative of those interested in the outcome of the standards development process, including manufacturers, consumers, utilities, states and representatives of environmental or energy efficiency interest groups.

(c) *DOE support of consensus development, including impact analyses.* In order to facilitate such consensus development, DOE will make available, upon request, appropriate technical and legal support to the group and will provide copies of all relevant public documents and analyses. The Department also will consider any requests for its active participation in such discussions, recognizing that the procedural requirements of the Federal Advisory Committee Act may apply to such participation.

9. Principles for the Conduct of Engineering Analysis

(a) The purpose of the engineering analysis is to develop the relationship between efficiency and cost of the subject product. The Department will use the most appropriate means available to determine the efficiency/cost relationship, including an overall system approach or engineering modeling to predict the improvement in efficiency that can be expected from individual design options as discussed in the paragraphs below. From this efficiency/cost relationship, measures such as payback, life cycle cost, and energy savings can be developed. The Department, in consultation with interested parties, will identify issues that will be examined in the engineering analysis and the types of specialized expertise that may be required. With these specifications, DOE will select appropriate contractors, subcontractors, and expert consultants, as necessary, to perform the engineering analysis and the impact analysis. Also, the Department will consider data, information and analyses received from interested parties for use in the analysis wherever feasible.

(b) The engineering analysis begins with the list of design options developed in consultation with the interested parties as a result of the screening process. In consultation with the technology/industry expert peer review group, the Department will establish the likely cost and performance improvement of each design option. Ranges and uncertainties of cost and performance will be established, although efforts will be made to minimize uncertainties by using measures such as test data or component or material supplier information where available. Estimated uncertainties will be carried forward in subsequent analyses. The use of quantitative models will be supplemented by qualitative assessments as appropriate.

(c) The next step includes identifying, modifying or developing any engineering models necessary to predict the efficiency impact of any one or combination of design options on the product. A base case configuration or starting point will be established as well as the order and combination/blending of the design options to be evaluated. The DOE, utilizing expert consultants, will then perform the engineering analysis and develop the cost efficiency curve for the product. The cost efficiency curve and any necessary models will be subject to peer review before being issued with the ANOPR.

10. Principles for the Analysis of Impacts on Manufacturers

(a) *Purpose.* The purpose of the manufacturer analysis is to identify the likely impacts of efficiency standards on manufacturers. The Department will analyze the impact of standards on manufacturers with substantial input from manufacturers and other interested parties. The use of quantitative models will be supplemented by qualitative assessments by industry experts. This section describes the principles that will be used in conducting future manufacturing impact analysis.

(b) *Issue identification.* In the impact analysis stage (section 4(d)), the Department, in consultation with interested parties, will identify issues that will require greater consideration in the detailed manufacturer impact analysis. Possible issues may include identification of specific types or groups of manufacturers and concerns over access to technology. Specialized contractor expertise, empirical data requirements, and analytical tools required to perform the manufacturer impact analysis also would be identified at this stage.

(c) *Industry characterization.* Prior to initiating detailed impact studies, the Department will seek input on the present and past industry structure and market characteristics. Input on the following issues will be sought:

(1) Manufacturers and their relative market shares;

(2) Manufacturer characteristics, such as whether manufacturers make a full line of models or serve a niche market;

(3) Trends in the number of manufacturers;

(4) Financial situation of manufacturers;

(5) Trends in product characteristics and retail markets; and

(6) Identification of other relevant regulatory actions and a description of the nature and timing of any likely impacts.

(d) *Cost impacts on manufacturers.* The costs of labor, material, engineering, tooling, and capital are difficult to estimate, manufacturer-specific, and usually proprietary. The Department will seek input from interested parties on the treatment of cost issues. Manufacturers will be encouraged to offer suggestions as to possible sources of data and appropriate data collection methodologies. Costing issues to be addressed include:

(1) Estimates of total cost impacts, including product-specific costs (based on cost impacts estimated for the engineering analysis) and front-end investment/conversion costs for the full range of product models.

(2) Range of uncertainties in estimates of average cost, considering alternative designs and technologies which may vary cost impacts and changes in costs of material, labor and other inputs which may vary costs.

(3) Variable cost impacts on particular types of manufacturers, considering factors such as atypical sunk costs or characteristics of specific models which may increase or decrease costs.

(e) *Impacts on product sales, features, prices and cost recovery.* In order to make manufacturer cash flow calculations, it is necessary to predict the number of products sold and their sale price. This requires an assessment of the likely impacts of price changes on the number of products sold and on typical features of models sold. Past analyses have relied on price and shipment data generated by economic models. The Department will develop additional estimates of prices and shipments by drawing on multiple sources of data and experience including: actual shipment and pricing experience, data from manufacturers, retailers and other market experts, financial models, and sensitivity analyses. The possible impacts of candidate standard levels on consumer choices among competing fuels will be explicitly considered where relevant.

(f) *Measures of impact.* The manufacturer impact analysis will estimate the impacts of candidate standard levels on the net cash flow of manufacturers. Computations will be performed for the industry as a whole and for typical and atypical manufacturers. The exact nature and the process by which the analysis will be conducted will be determined by DOE, in conjunction with interested parties. Impacts to be analyzed include:

(1) Industry net present value, with sensitivity analyses based on uncertainty of costs, sales prices and sales volumes;

(2) Cash flows, by year;

(3) Other measures of impact, such as revenue, net income and return on equity, as appropriate;

The characteristics of atypical manufacturers worthy of special consideration will be determined in consultation with manufacturers and other interested parties and may include: manufacturers incurring higher or lower than average costs; and manufacturers experiencing greater or fewer adverse impacts on sales. Alternative scenarios based on other methods of estimating cost or sales impacts also will be performed, as needed.

(g) *Cumulative impacts of other Federal regulatory actions.* (1) The Department will recognize and seek to mitigate the overlapping effects on manufacturers of new or revised DOE standards and other regulatory actions affecting the same products. DOE will analyze and consider the impact on manufacturers of multiple product-specific regulatory actions. These factors will be considered in setting rulemaking priorities, assessing manufacturer impacts of a particular standard, and establishing the effective date for a new or revised standard. In particular, DOE will seek to propose effective dates for new or revised standards that are appropriately coordinated with other regulatory actions to mitigate any cumulative burden.

(2) If the Department determines that a proposed standard would impose a significant impact on product manufacturers within three years of the effective date of another DOE standard that imposes significant impacts on the same manufacturers (or divisions thereof, as appropriate), the Department will, in addition to evaluating the impact on manufacturers of the proposed standard, assess the joint impacts of both standards on manufacturers.

(3) If the Department is directed to establish or revise standards for products that are components of other products subject to standards, the Department will consider the interaction between such standards in setting rulemaking priorities and assessing manufacturer impacts of a particular standard. The Department will assess, as part of the engineering and impact analyses, the cost of components subject to efficiency standards.

(h) *Summary of quantitative and qualitative assessments.* The summary of quantitative and qualitative assessments will contain a description and discussion of uncertainties. Alternative estimates of impacts, resulting from the different potential scenarios developed throughout the analysis, will be explicitly presented in the final analysis results.

(i) *Key modeling and analytical tools.* In its assessment of the likely impacts of standards on manufacturers, the Department will use models which are clear and understandable, feature accessible calculations, and have assumptions that are clearly explained. As a starting point, the Department will use the Government Regulatory Impact Model (GRIM). The Department will consider any enhancements to the GRIM that are suggested by interested parties. If changes are made to the GRIM methodology, DOE will provide notice and seek public input. The Department will also support the development of economic models for price and volume forecasting. Research required to update key economic data will be considered.

11. Principles for the Analysis of Impacts on Consumers

(a) *Early consideration of impacts on consumer utility.* The Department will consider at the earliest stages of the development of a standard whether particular design options will lessen the utility of the covered products to the consumer. See section 4(a).

(b) *Impacts on product availability.* The Department will determine, based on consideration of information submitted during the standard development process, whether a proposed standard is likely to result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the U.S. at the time. DOE will not promulgate a standard if it concludes that it would result in such unavailability.

(c) *Department of justice review.* As required by law, the Department will solicit the views of the Justice Department on any lessening of competition that is likely to result from the imposition of a proposed standard and will give the views provided full consideration in assessing economic justification of a proposed standard. In addition, DOE may consult with the Department of Justice at earlier stages in the standards development process to seek to obtain preliminary views on competitive impacts.

(d) *Variation in consumer impacts.* The Department will use regional analysis and sensitivity analysis tools, as appropriate, to evaluate the potential distribution of impacts of candidate standards levels among different subgroups of consumers. The Department will consider impacts on significant segments of consumers in determining standards levels. Where there are significant negative impacts on identifiable subgroups, DOE will consider the efficacy of voluntary approaches as a means to achieve potential energy savings.

(e) *Payback period and first cost.* (1) In the assessment of consumer impacts of standards, the Department will consider Life-Cycle Cost, Payback Period and Cost of Conserved Energy to evaluate the savings in operating expenses relative to increases in purchase price. The Department intends to increase the level of sensitivity analysis and scenario analysis for future rulemakings. The results of these analyses will be carried throughout the analysis and the ensuing uncertainty described.

(2) If, in the analysis of consumer impacts, the Department determines that a candidate standard level would result in a substantial increase in the product first costs to consumers or would not pay back such additional first costs through energy cost savings in less than three years, Department will specifically assess the likely impacts of such a standard on low-income households, product sales and fuel switching.

12. Consideration of Non-Regulatory Approaches

(a) The Department recognizes that voluntary or other non-regulatory efforts by manufacturers, utilities and other interested parties can result in substantial efficiency improvements. The Department intends to consider fully the likely effects of non-regulatory initiatives on product energy use, consumer utility and life cycle costs, manufacturers, competition, utilities and the environment, as well as the distribution of these impacts among different regions, consumers, manufacturers and utilities. DOE will attempt to base its assessment on the actual impacts of such initiatives to date, but also will consider information presented regarding the impacts that any existing initiative might have in the future. Such information is likely to include a demonstration of the strong commitment of manufacturers, distribution channels, utilities or others to such voluntary efficiency improvements. This information will be used in assessing the likely incremental impacts of establishing or revising standards, in assessing appropriate effective dates for new or revised standards and in considering DOE support of non-regulatory initiatives.

(b) DOE believes that non-regulatory approaches are valuable complements to the standards program. In particular, DOE will consider pursuing voluntary programs where it appears that highly efficient products can obtain a significant market share but less efficient products cannot be eliminated altogether because, for instance, of unacceptable adverse impacts on a significant subgroup of consumers. In making this assessment, the Department will consider the success more efficient designs have had in the market, their acceptance to date, and their potential market penetration.

13. Crosscutting Analytical Assumptions

In selecting values for certain crosscutting analytical assumptions, DOE expects to continue relying upon the following sources and general principles:

(a) *Underlying economic assumptions.* The appliance standards analyses will generally use the same economic growth and development assumptions that underlie the most current Annual Energy Outlook (AEO) published by the Energy Information Administration (EIA).

(b) *Energy price and demand trends.* Analyses of the likely impact of appliance standards on typical users will generally adopt the mid-range energy price and demand scenario of the EIA's most current AEO. The sensitivity of such estimated impacts to possible variations in future energy prices are likely to be examined using the EIA's high and low energy price scenarios.

(c) *Product-specific energy-efficiency trends, without updated standards.* Product specific energy-efficiency trends will be based on a combination of the efficiency trends forecast by the EIA's residential and commercial demand model of the National Energy Modeling System (NEMS) and product-specific assessments by DOE and its contractors with input from interested parties.

(d) *Discount rates.* For residential and commercial consumers, ranges of three different real discount rates will be used. For residential consumers, the mid-range discount rate will represent DOE's approximation of the average financing cost (or opportunity costs of reduced savings) experienced by typical consumers. Sensitivity analyses will be performed using discount rates reflecting the costs more likely to be experienced by residential consumers with little or no savings and credit card financing and consumers with substantial savings. For commercial users, a mid-range discount rate reflecting the DOE's approximation of the average real rate of return on commercial investment will be used, with sensitivity analyses being performed using values indicative of the range of real rates of return likely to be experienced by typical commercial businesses. For national net present value calculations, DOE would use the Administration's approximation of the average real rate of return on private investment in the U.S. economy. For manufacturer impacts, DOE plans to use a range of real discount rates which are representative of the real rates of return experienced by typical U.S. manufacturers affected by the program.

(e) *Environmental impacts.* The emission rates of carbon, sulfur oxides and nitrogen oxides used by DOE to calculate the physical quantities of emissions likely to be avoided by candidate standard levels will be based on the current average carbon emissions of the U.S. electric utilities and on the projected rates of emissions of sulfur and nitrogen oxides. Projected rates of emissions, if available, will be used for the estimation of any other environmental impacts. The Department will consider the effects of the proposed standards on these emissions in reaching a decision about whether the benefits of the proposed standards exceed their burdens but will not determine the monetary value of these environmental externalities.

14. Deviations, Revisions, and Judicial Review

(a) *Deviations.* This appendix specifies procedures, interpretations and policies for the development of new or revised energy efficiency standards in considerable detail. As the approach described in this appendix is applied to the development of particular standards, the Department may find it necessary or appropriate to deviate from these procedures, interpretations or policies. If the Department concludes that such deviations are necessary or appropriate in a particular situation, DOE will provide interested parties with notice of the deviation and an explanation.

(b) *Revisions.* If the Department concludes that changes to the procedures, interpretations or policies in this appendix are necessary or appropriate, DOE will provide notice in the FEDERAL REGISTER of modifications to this appendix with an accompanying explanation. DOE expects to consult with interested parties prior to any such modification.

(c) *Judicial review.* The procedures, interpretations, and policies stated in this appendix are not intended to establish any new cause of action or right to judicial review.

[61 FR 36981, July 15, 1996]

Subpart D—Petitions To Exempt State Regulation From Preemption; Petitions To Withdraw Exemption of State Regulation

SOURCE: 54 FR 6078, Feb. 7, 1989, unless otherwise noted.

§ 430.40 Purpose and scope.

(a) This subpart prescribes the procedures to be followed in connection with petitions requesting a rule that a State regulation prescribing an energy conservation standard, water conservation standard (in the case of faucets, showerheads, water closets, and urinals), or other requirement respecting energy efficiency, energy use, or water use (in the case of faucets, showerheads, water closets, and urinals) of a type (or class) of covered product not be preempted.

(b) This subpart also prescribes the procedures to be followed in connection with petitions to withdraw a rule exempting a State regulation prescribing an energy conservation standard, water conservation standard (in the case of faucets, showerheads, water closets, and urinals), or other requirement respecting energy efficiency, energy use, or water use (in the case of faucets, showerheads, water closets, and urinals) of a type (or class) of covered product.

[63 FR 13318, Mar. 18, 1998]

§ 430.41 Prescriptions of a rule.

(a) *Criteria for exemption from preemption.* Upon petition by a State which has prescribed an energy conservation standard, water conservation standard (in the case of faucets, showerheads, water closets, and urinals), or other requirement for a type or class of covered equipment for which a Federal energy conservation standard or water conservation standard is applicable, the Secretary shall prescribe a rule that such standard not be preempted if he determines that the State has established by a preponderance of evidence that such requirement is needed to meet unusual and compelling State or local energy interests or water interests. For the purposes of this section, the term ''unusual and compelling State or local energy interests or water interests'' means interests which are substantially different in nature or magnitude than those prevailing in the U.S. generally, and are such that when evaluated within the context of the State's energy plan and forecast, or water plan and forecast the costs, benefits, burdens, and reliability of energy savings or water savings resulting from the State regulation make such regulation preferable or necessary when measured against the costs, benefits, burdens, and reliability of alternative approaches to energy savings or water savings or production, including reliance on reasonably predictable market-induced improvements in efficiency of all equipment subject to the State regulation. The Secretary may not prescribe such a rule if he finds that interested persons have established, by a preponderance of the evidence, that the State's regulation will significantly burden manufacturing, marketing, distribution, sale or servicing of the covered equipment on a national basis. In determining whether to make such a finding, the Secretary shall evaluate all relevant factors including: the extent to which the State regulation will increase manufacturing or distribution costs of manufacturers, distributors, and others; the extent to which the State regulation will disadvantage smaller manufacturers, distributors, or dealers or lessen competition in the sale of the covered product in the State; the extent to which the State regulation would cause a burden to manufacturers to redesign and produce the covered product type (or class), taking into consideration the extent to which the regulation would result in a reduction in the current models, or in the projected availability of models, that could be shipped on the effective date of the regulation to the State and within the U.S., or in the current or projected sales volume of the covered product type (or class) in the State and the U.S.; and the extent to which the State regulation is likely to contribute significantly to a proliferation of State appliance efficiency requirements and the cumulative impact such requirements would have. The Secretary may not prescribe such a rule if he finds that such a rule will result in the unavailability in the State of any covered product (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the State at the time of the Secretary's finding. The failure of some classes (or types) to meet this criterion shall not affect the Secretary's determination of whether to prescribe a rule for other classes (or types).

(1) *Requirements of petition for exemption from preemption.* A petition from a State for a rule for exemption from preemption shall include the information listed in paragraphs (a)(1)(i) through (a)(1)(vi) of this section. A petition for a rule and correspondence relating to such petition shall be available for public review except for confidential or proprietary information submitted in accordance with the Department of Energy's Freedom of Information Regulations set forth in 10 CFR part 1004:

(i) The name, address, and telephone number of the petitioner;

(ii) A copy of the State standard for which a rule exempting such standard is sought;

(iii) A copy of the State's energy plan or water plan and forecast;

(iv) Specification of each type or class of covered product for which a rule exempting a standard is sought;

(v) Other information, if any, believed to be pertinent by the petitioner; and

(vi) Such other information as the Secretary may require.

(2) [Reserved]

(b) *Criteria for exemption from preemption when energy emergency conditions or water emergency conditions (in the case of faucets, showerheads, water closets, and urinals) exist within State.* Upon petition by a State which has prescribed an energy conservation standard or water conservation standard (in the case of faucets, showerheads, water closets, and urinals) or other requirement for a type or class of covered product for which a Federal energy conservation standard or water conservation standard is applicable, the Secretary may prescribe a rule, effective upon publication in the FEDERAL REGISTER, that such State regulation not be preempted if he determines that in addition to meeting the requirements of paragraph (a) of this section the State has established that: an energy emergency condition or water emergency condition exists within the State that imperils the health, safety, and welfare of its residents because of the inability of the State or utilities within the State to provide adequate quantities of gas, electric energy, or water to its residents at less than prohibitive costs; and cannot be substantially alleviated by the importation of energy or water or the use of interconnection agreements; and the State regulation is necessary to alleviate substantially such condition.

(1) *Requirements of petition for exemption from preemption when energy emergency conditions or water emergency conditions (in the case of faucets, showerheads, water closets, and urinals) exist within a State.* A petition from a State for a rule for exemption from preemption when energy emergency conditions or water emergency conditions exist within a State shall include the information listed in paragraphs (a)(1)(i) through (a)(1)(vi) of this section. A petition shall also include the information prescribed in paragraphs (b)(1)(i) through (b)(1)(iv) of this section, and shall be available for public review except for confidential or proprietary information submitted in accordance with the Department of Energy's Freedom of Information Regulations set forth in 10 CFR part 1004:

(i) A description of the energy emergency condition or water emergency condition (in the case of faucets, showerheads, water closets, and urinals) which exists within the State, including causes and impacts.

(ii) A description of emergency response actions taken by the State and utilities within the State to alleviate the emergency condition;

(iii) An analysis of why the emergency condition cannot be alleviated substantially by importation of energy or water or the use of interconnection agreements; and

(iv) An analysis of how the State standard can alleviate substantially such emergency condition.

(2) [Reserved]

(c) *Criteria for withdrawal of a rule exempting a State standard.* Any person subject to a State standard which, by rule, has been exempted from Federal preemption and which prescribes an energy conservation standard or water conservation standard (in the case of faucets, showerheads, water closets, and urinals) or other requirement for a type or class of a covered product, when the Federal energy conservation standard or water conservation standard (in the case of faucets, showerheads, water closets, and urinals) for such product subsequently is amended, may petition the Secretary requesting that the exemption rule be withdrawn. The Secretary shall consider such petition in accordance with the requirements of paragraph (a) of this section, except that the burden shall be on the petitioner to demonstrate that the exemption rule received by the State should be withdrawn as a result of the amendment to the Federal standard. The Secretary shall withdraw such rule if he determines that the petitioner has shown the rule should be withdrawn.

(1) *Requirements of petition to withdraw a rule exempting a State standard.* A petition for a rule to withdraw a rule exempting a State standard shall include the information prescribed in paragraphs (c)(1)(i) through (c)(1)(vii) of this section, and shall be available for public review, except for confidential or proprietary information submitted in accordance with the Department of Energy's Freedom of Information Regulations set forth in 10 CFR part 1004:

(i) The name, address and telephone number of the petitioner;

(ii) A statement of the interest of the petitioner for which a rule withdrawing an exemption is sought;

(iii) A copy of the State standard for which a rule withdrawing an exemption is sought;

(iv) Specification of each type or class of covered product for which a rule withdrawing an exemption is sought;

(v) A discussion of the factors contained in paragraph (a) of this section;

(vi) Such other information, if any, believed to be pertinent by the petitioner; and

(vii) Such other information as the Secretary may require.

(2) [Reserved]

[63 FR 13318, Mar. 18, 1998]

§ 430.42 Filing requirements.

(a) *Service.* All documents required to be served under this subpart shall, if mailed, be served by first class mail. Service upon a person's duly authorized representative shall constitute service upon that person.

(b) *Obligation to supply information.* A person or State submitting a petition is under a continuing obligation to provide any new or newly discovered information relevant to that petition. Such information includes, but is not limited to, information regarding any other petition or request for action subsequently submitted by that person or State.

(c) *The same or related matters.* A person or State submitting a petition or other request for action shall state whether to the best knowledge of that petitioner the same or related issue, act, or transaction has been or presently is being considered or investigated by any State agency, department, or instrumentality.

(d) *Computation of time.* (1) Computing any period of time prescribed by or allowed under this subpart, the day of the action from which the designated period of time begins to run is not to be included. If the last day of the period is Saturday, or Sunday, or Federal legal holiday, the period runs until the end of the next day that is neither a Saturday, or Sunday or Federal legal holiday.

(2) Saturdays, Sundays, and intervening Federal legal holidays shall be excluded from the computation of time when the period of time allowed or prescribed is 7 days or less.

(3) When a submission is required to be made within a prescribed time, DOE may grant an extension of time upon good cause shown.

(4) Documents received after regular business hours are deemed to have been submitted on the next regular business day. Regular business hours for the DOE's National Office, Washington, DC, are 8:30 a.m. to 4:30 p.m.

(5) DOE reserves the right to refuse to accept, and not to consider, untimely submissions.

(e) *Filing of petitions.* (1) A petition for a rule shall be submitted in triplicate to: The Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy, Section 327 Petitions, Appliance Efficiency Standards, Forrestal Building, 1000 Independence Avenue, SW., Washington, DC 20585.

(2) A petition may be submitted on behalf of more than one person. A joint petition shall indicate each person participating in the submission. A joint petition shall provide the information required by § 430.41 for each person on whose behalf the petition is submitted.

(3) All petitions shall be signed by the person(s) submitting the petition or by a duly authorized representative. If submitted by a duly authorized representative, the petition shall certify this authorization.

(4) A petition for a rule to withdraw a rule exempting a State regulation, all supporting documents, and all future submissions shall be served on each State agency, department, or instrumentality whose regulation the petitioner seeks to supersede. The petition shall contain a certification of this service which states the name and mailing address of the served parties, and the date of service.

(f) *Acceptance for filing.* (1) Within fifteen (15) days of the receipt of a petition, the Secretary will either accept it for filing or reject it, and the petitioner will be so notified in writing. The Secretary will serve a copy of this notification on each other party served by the petitioner. Only such petitions which conform to the requirements of this subpart and which contain sufficient information for the purposes of a substantive decision will be accepted for filing. Petitions which do not so conform will be rejected and an explanation provided to petitioner in writing.

(2) For purposes of the Act and this subpart, a petition is deemed to be filed on the date it is accepted for filing.

(g) *Docket.* A petition accepted for filing will be assigned an appropriate docket designation. Petitioner shall use the docket designation in all subsequent submissions.

§ 430.43 Notice of petition.

(a) Promptly after receipt of a petition and its acceptance for filing, notice of such petition shall be published in the FEDERAL REGISTER. The notice shall set forth the availability for public review of all data and information available, and shall solicit comments, data and information with respect to the determination on the petition. Except as may otherwise be specified, the period for public comment shall be 60 days after the notice appears in the FEDERAL REGISTER.

(b) In addition to the material required under paragraph (a) of this section, each notice shall contain a summary of the State regulation at issue and the petitioner's reasons for the rule sought.

§430.44 Consolidation.

DOE may consolidate any or all matters at issue in two or more proceedings docketed where there exist common parties, common questions of fact and law, and where such consolidation would expedite or simplify consideration of the issues. Consolidation shall not affect the right of any party to raise issues that could have been raised if consolidation had not occurred.

§430.45 Hearing.

The Secretary may hold a public hearing, and publish notice in the FEDERAL REGISTER of the date and location of the hearing, when he determines that such a hearing is necessary and likely to result in a timely and effective resolution of the issues. A transcript shall be kept of any such hearing.

§430.46 Disposition of petitions.

(a) After the submission of public comments under §430.42(a), the Secretary shall prescribe a final rule or deny the petition within 6 months after the date the petition is filed.

(b) The final rule issued by the Secretary or a determination by the Secretary to deny the petition shall include a written statement setting forth his findings and conclusions, and the reasons and basis therefor. A copy of the Secretary's decision shall be sent to the petitioner and the affected State agency. The Secretary shall publish in the FEDERAL REGISTER a notice of the final rule granting or denying the petition and the reasons and basis therefor.

(c) If the Secretary finds that he cannot issue a final rule within the 6-month period pursuant to paragraph (a) of this section, he shall publish a notice in the FEDERAL REGISTER extending such period to a date certain, but no longer than one year after the date on which the petition was filed. Such notice shall include the reasons for the delay.

§430.47 Effective dates of final rules.

(a) A final rule exempting a State standard from Federal preemption will be effective:

(1) Upon publication in the FEDERAL REGISTER if the Secretary determines that such rule is needed to meet an ''energy emergency condition or water emergency condition (in the case of faucets, showerheads, water closets, and urinals)'' within the State.

(2) Three years after such rule is published in the FEDERAL REGISTER; or

(3) Five years after such rule is published in the FEDERAL REGISTER if the Secretary determines that such additional time is necessary due to the burdens of retooling, redesign or distribution.

(b) A final rule withdrawing a rule exempting a State standard will be effective upon publication in the FEDERAL REGISTER.

[54 FR 6078, Feb. 7, 1989, as amended at 63 FR 13319, Mar. 18, 1998]

§430.48 Request for reconsideration.

(a) Any petitioner whose petition for a rule has been denied may request reconsideration within 30 days of denial. The request shall contain a statement of facts and reasons supporting reconsideration and shall be submitted in writing to the Secretary.

(b) The denial of a petition will be reconsidered only where it is alleged and demonstrated that the denial was based on error in law or fact and that evidence of the error is found in the record of the proceedings.

(c) If the Secretary fails to take action on the request for reconsideration within 30 days, the request is deemed denied, and the petitioner may seek such judicial review as may be appropriate and available.

(d) A petitioner has not exhausted other administrative remedies until a request for reconsideration has been filed and acted upon or deemed denied.

§430.49 Finality of decision.

(a) A decision to prescribe a rule that a State energy conservation standard, water conservation standard (in the case of faucets, showerheads, water closets, and urinals) or other requirement not be preempted is final on the date the rule is issued, i.e., signed by the Secretary. A decision to prescribe such a rule has no effect on other regulations of a covered product of any other State.

(b) A decision to prescribe a rule withdrawing a rule exempting a State standard or other requirement is final on the date the rule is issued, i.e., signed by the Secretary. A decision to deny such a petition is final on the day a denial of a request for reconsideration is issued, i.e., signed by the Secretary.

[54 FR 6078, Feb. 7, 1989, as amended at 63 FR 13319, Mar. 18, 1998]

Subpart E—Small Business Exemptions

SOURCE: 54 FR 6080, Feb. 7, 1989, unless otherwise noted.

§ 430.50 Purpose and scope.

(a) This subpart establishes procedures for the submission and disposition of applications filed by manufacturers of covered consumer products with annual gross revenues that do not exceed $8 million to exempt them temporarily from all or part of energy conservation standards or water conservation standards (in the case of faucets, showerheads, water closets, and urinals) established by this part.

(b) The purpose of this subpart is to provide content and format requirements for manufacturers of covered consumer products with low annual gross revenues who desire to apply for temporary exemptions from applicable energy conservation standards or water conservation standards (in the case of faucets, showerheads, water closets, and urinals) .

[54 FR 6080, Feb. 7, 1989, as amended at 63 FR 13319, Mar. 18, 1998]

§ 430.51 Eligibility.

Any manufacturer of a covered product with annual gross revenues that do not exceed $8,000,000 from all its operations (including the manufacture and sale of covered products) for the 12-month period preceding the date of application may apply for an exemption. In determining the annual gross revenues of any manufacturer under this subpart, the annual gross revenue of any other person who controls, is controlled, by, or is under common control with, such manufacturer shall be taken into account.

§ 430.52 Requirements for applications.

(a) Each application filed under this subpart shall be submitted in triplicate to: U.S. Department of Energy, Small Business Exemptions, Appliance Efficiency Standards, Assistant Secretary for Conservation and Renewable Energy, Forrestal Building, 1000 Independence Avenue, SW., Washington, DC 20585.

(b) An application shall be in writing and shall include the following:

(1) Name and mailing address of applicant;

(2) Whether the applicant controls, is controlled by, or is under common control with another manufacturer, and if so, the nature of that control relationship;

(3) The text or substance of the standard or portion thereof for which the exemption is sought and the length of time desired for the exemption;

(4) Information showing the annual gross revenue of the applicant for the preceding 12-month period from all of its operations (including the manufacture and sale of covered products):

(5) Information to show that failure to grant an exemption is likely to result in a lessening of competition;

(6) Such other information, if any, believed to be pertinent by the petitioner; and

(7) Such other information as the Secretary may require.

§ 430.53 Processing of applications.

(a) The applicant shall serve a copy of the application, all supporting documents and all subsequent submissions, or a copy from which confidential information has been deleted pursuant to 10 CFR 1004.11, to the Secretary, which may be made available for public review.

(b) Within fifteen (15) days of the receipt of an application, the Secretary will either accept it for filing or reject it, and the applicant will be so notified in writing. Only such applications which conform to the requirements of this subpart and which contain sufficient information for the purposes of a substantive decision will be accepted for filing. Applications which do not so conform will be rejected and an explanation provided to the applicant in writing.

(c) For the purpose of this subpart, an application is deemed to be filed on the date it is accepted for filing.

(d) Promptly after receipt of an application and its acceptance for filing, notice of such application shall be published in the FEDERAL REGISTER. The notice shall set forth the availability for public review of data and information available, and shall solicit comments, data and information with respect to the determination on the application. Except as may otherwise be specified, the period for public comment shall be 60 days after the notice appears in the FEDERAL REGISTER.

(e) The Secretary on his own initiative may convene a hearing if, in his discretion, he considers such hearing will advance his evaluation of the application.

§ 430.54 Referral to the Attorney General.

Notice of the application for exemption under this subpart shall be transmitted to the Attorney General by the Secretary and shall contain (a) a statement of the facts and of the reasons for the exemption, and (b) copies of all documents submitted.

§ 430.55 Evaluation of application.

The Secretary shall grant an application for exemption submitted under this subpart if the Secretary finds, after obtaining the written views of the Attorney General, that a failure to allow an exemption would likely result in a lessening of competition.

§ 430.56 Decision and order.

(a) Upon consideration of the application and other relevant information received or obtained, the Secretary shall issue an order granting or denying the application.

(b) The order shall include a written statement setting forth the relevant facts and the legal basis of the order.

(c) The Secretary shall serve a copy of the order upon the applicant and upon any other person readily identifiable by the Secretary as one who is interested in or aggrieved by such order. The Secretary also shall publish in the FEDERAL REGISTER a notice of the grant or denial of the order and the reason therefor.

§ 430.57 Duration of temporary exemption.

A temporary exemption terminates according to its terms but not later than twenty-four months after the affective date of the rule for which the exemption is allowed.

Subpart F [Reserved]

§§ 430.60–430.75 [Reserved]

APPENDICES A–B TO SUBPART F OF PART 430 [RESERVED]

PART 431—ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT