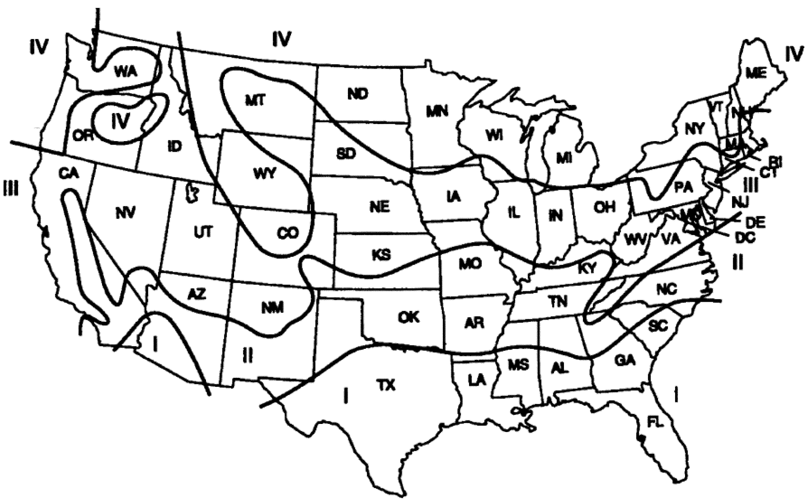
Figure 3: Weather Regions for the United States



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

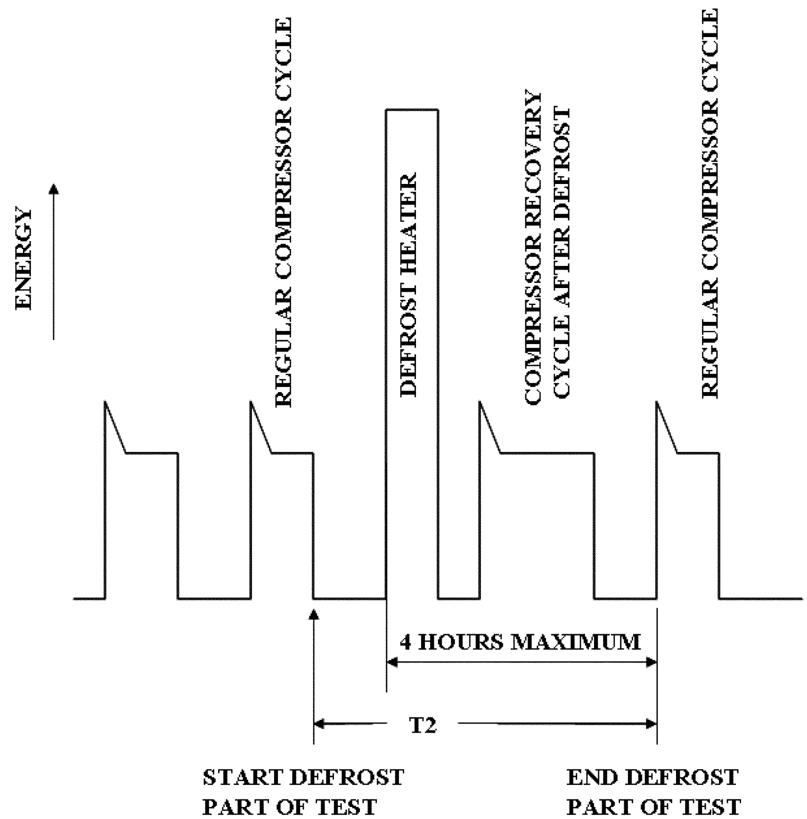
Tests shall be performed by establishing the conditions set forth in section 2, and using the control settings set forth in section 3.

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

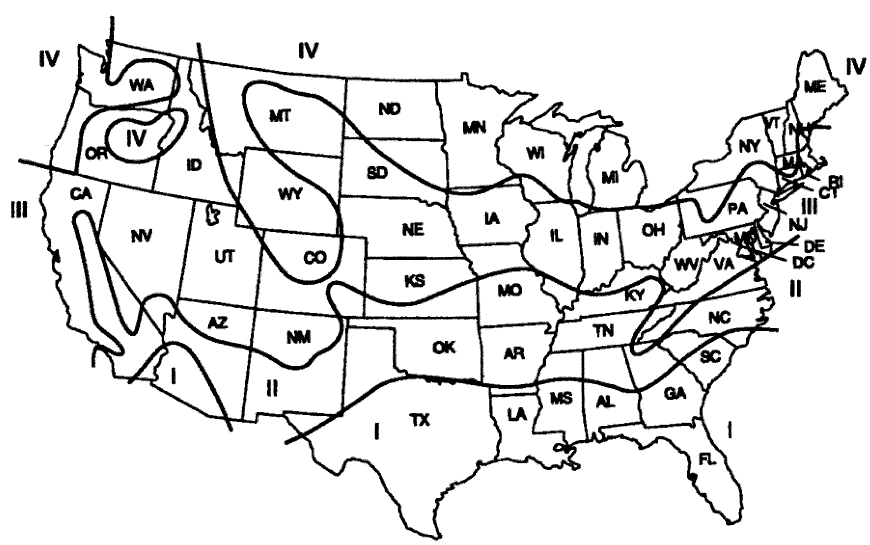
a_1, a, b, c, d, e are weather associated weighting factors for the Regions, as specified in Table A:

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.