ENERGY STAR® Program Requirements Product Specification for Laboratory Grade Refrigerators and Freezers, and Ultra-LowTemperature Freezers

Draft 2 Test Method Rev. Sept-2013

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Eligibility Criteria for Laboratory Grade Refrigerators (LGR) and Freezers (LGF), and Ultra-Low Temperature Freezers (ULF).

2 APPLICABILITY

ENERGY STAR test requirements are dependent upon the feature set of the product under evaluation. The following guidelines shall be used to determine the applicability of each section of this document

This test method is applicable to LGRs, LGFs, and ULFs, specifically:

- LGRs: general purpose laboratory refrigerators, blood bank refrigerators, pharmacy and chromatography refrigerators,
- LGFs: general purpose laboratory freezers, -30 ºC freezers, -20 ºC freezers, and
- ULFs: freezers that maintain storage temperatures between -70 °C and -80 °C.

This test method does not include portable laboratory refrigerators and freezers, explosion proof refrigerators and freezers, and walk-in laboratory refrigerators. This test procedure is applicable to units with manual, automatic-timed, and automatic-smart or on demand defrost systems.

3 DEFINITIONS

A) Product Types:

1) Laboratory Grade Freezer (LGF): A refrigerated cabinet used for storing volatile reagents and biological specimens at setpoint temperatures between -40 °C and 0 °C (-40 °F and 32 °F), typically marketed through laboratory equipment supply stores for laboratory and medical use.

2) Laboratory Grade Refrigerator (LGR): A refrigerated cabinet used for storing non-volatile reagents and biological specimens at setpoint temperatures between 0 °C and 12 °C (32 °F and 53.6 °F), typically marketed through laboratory equipment supply stores for laboratory or medical use.

3) Ultra-Low-Temperature Laboratory Freezer (ULF): A freezer designed for laboratory application that is capable of maintaining setpoint storage temperatures between -70 °C and -80 °C (-94 °F and -112 °F).

Note: U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) are interested in stakeholder feedback regarding the proposed product types (LGF, LGR, and ULF) and any other product types that should be defined here in the Test Method.

B) Defrost-related Terms:

1) Automatic Defrost: 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 defrost water is disposed of automatically.

2) Variable Defrost: A 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.

3) Manual Defrost: A system in which the defrost cycle is initiated and terminated manually.

4) Semi-Automatic Defrost: A system in which the defrost cycle is manually initiated and automatically terminated, with automatic resumption of normal refrigeration at the conclusion of the defrost operation.

Note: DOE has updated the definitions for defrost-related terms to provide additional clarification. DOE and EPA are interested in stakeholder feedback regarding the updated definitions and their applicability to LGRs, LGFs, and ULFs.

C) Additional Terms:

5) Cabinet Temperature: The average of all temperature measurements taken inside a product's cabinet at any given time.

6) Peak Variance: The difference between the maximum and minimum temperatures measured across all thermocouples over the course of a given measurement period.

7) Refrigeration Cycle: The period of time from when the unit's refrigeration system turns on, through the time it turns off, until it turns on again (e.g., a compressor cycle).

8) Running Cycle: The period of time between the first time the unit's refrigeration system turns on after a defrost termination and the beginning of the next successive defrost.

9) Stability: The difference between the maximum and minimum temperature measured by a given thermocouple over the course of the entire test period.

10) Steady-State: The condition where the average of all Cabinet Temperatures measured during a single Refrigeration Cycle or, for those units that do not cycle, during a single 24-hour period, , changes less than ± 0.5 ºC (0.9 ºF) from one Refrigeration Cycle or 24-hour period (respectively) to the next.

Note: Stakeholders commented that the Steady State requirements specified in the ENERGY STAR Laboratory Grade Refrigerators and Freezers and Ultra-Low Temperature Freezers Draft 1 Test Method (Draft 1 Test Method) were too stringent and recommended alternate requirements, ranging from 0.5 °C to several degrees Celsius. The Draft 1 Test Method requirements were based on the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. ASHRAE standard 72-2005, Method of Testing Commercial Refrigerators and Freezers, which requires a change of less ± 0.2 °C (0.4 ºF). However, based on stakeholder comments DOE performed validation testing on several different units to evaluate the performance of LGRs, LGFs, and ULFs during normal operation. As part of this testing, the units were allowed to run under normal conditions without door openings for several days. Validation testing showed that not all of the units were able to meet the Steady State requirements specified in the Draft 1 Test Method depending on the 24-hour periods evaluated, but all of the units were able to maintain an average temperature with changes less than ± 0.5 ºC (0.9 ºF) regardless of the 24-hour periods evaluated. In addition, the difference in average power draw between the 24-hour periods with the highest and lowest average temperatures for each unit was less than 3 percent, suggesting that variations in average temperature within this specified tolerance do not significantly affect energy consumption ratings. Based on this validation testing, DOE has updated the Steady State requirements to state that the Cabinet Temperature shall change less than ± 0.5 °C (0.9 ºF) from one 24-hour period or Refrigeration Cycle to the next. DOE believes this change will reduce test burden without affecting the reported energy consumption of tested units. DOE is interested in stakeholder feedback regarding the new Steady State requirements.

11) Test: A 24-hour period over which measurements are taken and energy use evaluated under one set of conditions after Steady State conditions occur as described in this test procedure.

12) Uniformity: The difference between the maximum and minimum temperature measured inside of a unit's cabinet at any given time.

D) Acronyms:

1) AHAM: Association of Home Appliance Manufacturers

2) ANSI: American National Standards Institute

3) LGF: Laboratory Grade Freezer

4) LGR: Laboratory Grade Refrigerator

5) NIST: National Institute of Standards and Technology

6) ULF: Ultra-Low Temperature Laboratory Freezer

7) UUT: Unit Under Test

4 TEST CONDITIONS

A) Power Supply: The power supply shall be maintained at the rated voltage ± 4.0 percent and rated frequency ± 1 percent. The actual voltage shall be recorded as measured at the product service connection with the refrigeration system in operation (for units with multiple compressors, with all compressor motors in operation).

B) Ambient Conditions:

1) Dry-bulb Temperature: The average test-room dry-bulb temperature shall be 24.0 ºC ± 1.0 ºC (75.2 ºF ± 1.8 ºF), when measured in accordance with Section 5 of this test procedure. Individual recorded temperatures shall be 24.0 ºC ± 2.0 ºC (75.2 ºF ± 3.6 ºF).

2) Wet-bulb Temperature: The test-room wet-bulb temperature shall be 18.0 ºC ± 1.0 ºC (64.4 ºF ± 1.8 ºF), when measured in accordance with Section 5 of this test procedure. Individual recorded temperatures shall be 18.0 ºC ± 2.0 ºC (64.4 ºF ± 3.6 ºF).

3) Dry-bulb Temperature Gradient: The dry-bulb temperature gradient shall be less than 2.0 ºC per m (1.0 ºF per foot) between T_A *and* T_B as defined in Section 5 of this test procedure.

4) Air Currents: Test room air currents across the display opening shall not exceed 0.25 m/s (49 fpm) as measured at T_B. No external air drafts shall blow directly into the refrigerated zone.

Note: Stakeholders commented that the lighting and radiant heat requirements from ASHRAE 72 are not necessary, as they do not have any noticeable effect on the energy consumption of these units. DOE believes that these requirements were included in ASHRAE 72 because they were pertinent to open-case refrigerators and freezers, but that variations in levels of lighting and radiant heat that would typically be found in a laboratory or test site would not have a significant effect on the energy consumption of closed-door LGRs, LGFs, or ULFs. (DOE is not aware of any open-case LGRs, LGFs, or ULFs.) DOE notes that the DOE Residential Refrigerators and Freezers Regulatory Test Procedure (as codified in Appendix A to Subpart B of 10 CFR Part 430) does not include lighting or radiant heat requirements. Because DOE does not have a justification for including lighting and radiant heat requirements, DOE has removed those requirements from the Draft 2 Test Method. All other ambient condition requirements have been retained and mirror those in ASHRAE 72. DOE requests stakeholder feedback regarding the proposed updates to the ambient condition requirements.

C) Instrument Requirements:

1) Electrical energy measurements shall be made with instruments accurate to ± 2 percent of the quantity measured.

2) Accuracy of all temperature measurements shall be within ± 0.8 °C (± 1.4 °F) of the measured value.

3) Time measurements shall be made with an accuracy of ± 0.5 percent of the time period being measured.

4) Air velocity shall be measured with an instrument having an accuracy of ± 10 percent.

5 TEST SETUP

A) Volume Measurements: The volume of each covered commercial refrigerator, freezer, or refrigerator-freezer shall be determined using the methodology set forth in the ANSI/AHAM HRF-1-2008. Computer-aided design (CAD) models can be used to determine the useable volume, as long as the drawings allow measurements and calculations to be made based on the volume measurement requirements specified in ANSI/AHAM HRF-1-2008.

Note: DOE has updated the volume measurement requirements to reference ANSI/AHAM HRF-1-2008, an industry test method commonly used for refrigerators and freezers. DOE requests stakeholder feedback regarding the updates to the volume measurement requirements.

Stakeholders requested that the Test Method allow the net usable volume to be determined using CAD drawings. DOE agrees that CAD models can be used to determine the useable volume, as long as measurements and calculations are made based on drawings that meet the requirements specified in ANSI/AHAM HRF-1-2008.

B) UUT Configuration: The cabinet with its refrigerating mechanism shall be assembled and set up in accordance with the printed instructions supplied with the cabinet. All packing materials and skid boards shall be removed. Chiller or drip trays shall be in their proper places during all tests. Outer door gaskets shall be checked for adequacy of seal to the cabinet and adjusted, if required. Containers, covers, and shelves shall not be removed. Unless otherwise specified, the following conditions apply:

1) Any operational mode that reduces energy usage during energy consumption testing and not during normal usage shall be disabled for energy consumption testing.

2) Representative shelving shall be used during testing. If the UUT offers more than one type of shelf or shelf configuration, labs must test and report each option / configuration separately. If a UUT offers drawers or baskets, that configuration must also be tested separately.

C) Accessories: All accessories shipped with the unit shall be installed prior to testing. During the test period, all standard components, such as shelves, end enclosures, lights, anti-condensate heaters, racks, monitoring devices, alarms, and similar items that would normally be used during working periods, shall be installed and used as recommended by the manufacturer.

1) All manually controlled accessories that come standard with the equipment shall be installed and turned to the "ON" position during testing.

D) Ambient Temperatures: The ambient dry-bulb temperature shall be measured at the following locations:

1) For Upright UUTs: Two locations in front of the UUT along a vertical line at the centerline of the UUT. The ambient measurement line extends from a point, T_A, which is 150 mm ± 50 mm (5.9 in. ± 2 in.) above the highest point on the UUT, down to the geometric center of the door opening, T_B. If there are multiple outer doors, T_B, shall be at the geometric center of all door openings. Both points are located 915 mm ± 15 mm (36 in. ± 2 in.) out from the door opening.

2) For Chest-type UUTs: Two locations along a horizontal line at the centerline of the UUT. The ambient measurement line across the door in the longest dimension (either width or depth) from a point, T_A, which is 150 mm ± 50 mm (5.9 in. ± 2 in.) beyond the door edge farthest from the door's geometric center, across to the geometric center of the door opening, T_B, Both points are located 915 mm ± 15 mm (36 in. ± 2 in.) above the door opening.

3) If placing a thermocouple at any point, T_A or T_B, interferes with the opening of the door, the thermocouple shall be moved away from the UUT, perpendicular to the plane of the door opening, until it no longer interferes with the door opening.

4) These points shall be selected such that they are not affected by external or UUT heat sources, such as condensing units, ballasts, heaters, or lights.

Note: During validation testing, DOE noted that the Draft 1 Test Method did not specify where to place the ambient temperature thermocouples when testing a chest-type UUT. DOE also noted that, for some UUTs, the distance from the thermocouples and the UUT's door did not allow the door to be fully opened. Based on these observations, DOE has updated the ambient temperature thermocouple placement requirements to accommodate chest-type UUT's and UUT's with wider doors. DOE is interested in stakeholder feedback regarding the proposed ambient thermocouple locations.

E) Placement of Thermocouples: The UUT shall be filled with un-weighted bare thermocouples as follows. Thermocouples shall be routed into the cabinet using an access port whenever possible.

Note: Stakeholders commented that staying within the Set-Point Temperature tolerances specified in Table 1 would be extremely difficult when using un-weighted thermocouples. DOE performed additional testing to evaluate the effect of un-weighted versus weighted thermocouples on the Cabinet Temperature over the course of a test. Testing showed that un-weighted and weighted thermocouples measured the same overall average cabinet temperature over the course of a test. As such, DOE has retained the requirement to use un-weighted bare thermocouples to reduce overall test burden. DOE emphasizes that the Set-Point Temperature tolerances are based on the overall average of all cabinet temperature measurements taken over the course of a test.

Stakeholders also commented that thermocouples should be routed into the cabinet through an access port whenever possible. DOE agrees with this comment and has updated the Draft 2 Test Method to specify as such. DOE requests stakeholder feedback regarding an appropriate way to route thermocouples into a cabinet without an access port.

1) Thermocouple Locations (Upright UUTs with shelves/drawers): Thermocouples shall be placed on three planes located 3 in. ± 1 in. above the topmost shelf/drawer, the middle shelf/drawer, and the bottom of the UUT, or 3 in. ± 1 in. above the bottom drawer or basket. Thermocouples shall be placed in the geometric center and 3 in. ± 1 in. diagonally from each corner of each plane (5 sensors per plane). For level, adjacent shelves within a UUT, the plane shall extend across all shelves. For level, adjacent baskets within a UUT, thermocouples shall be placed at the geometric center of each basket.

   a. If the UUT does not have inner doors, three shelves/drawers should be placed in the (1) top allowable position, (2) geometric center, and (3) lowest allowable position.

   b. If the UUT has inner doors, shelves should be evenly placed in the standard locations based on the inner doors. If placing the thermocouples in three planes as instructed above would result in any compartment created by the inner doors not containing thermocouples, add one plane of thermocouples 3 in. ± 1 in. from the bottom of that compartment.

   c. If the location of any thermocouple interferes with any hardware built into the UUT, move that plane of thermocouples up or down until the thermocouples are at least 2 inches away from the hardware.

2) Thermocouple Locations (Upright UUTs without shelves/drawers): If a UUT is sold without shelving/drawers, then the lab may test it without shelves/drawers. Thermocouples shall be placed a plane located 3 in. ± 1 in. from the top of the UUT, 3 in. ± 1 in. from the bottom of the UUT, and at the geometric center of the UUT, If this configuration is such that the distance between planes is greater than either the interior width or the interior depth of the UUT, add additional planes and evenly space the middle planes between the top and bottom plane until the distance between planes is less than either the height or depth of the UUT. Thermocouples shall be placed in the geometric center and 3 in. ± 1 in. diagonally from each corner of each plane (5 sensors per plane).

   a. If the location of any thermocouple interferes with any hardware built into the UUT, move that plane of thermocouples along the height of the UUT until the thermocouples are at least 2 inches away from the hardware.

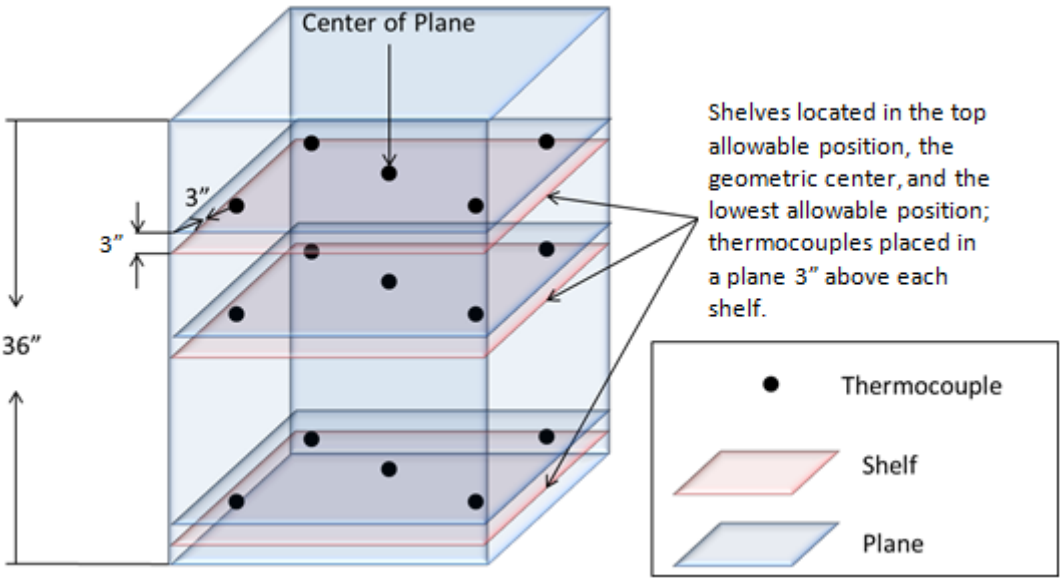

Figure 1: Example of Placement of Thermocouples in Upright Refrigerator with Shelves

3) Thermocouple Locations (Chest UUTs): Thermocouples shall be located in planes 3 in. ± 1 in. from the left end, 3 in. ± 1 in. from the right end, and at the geometric center of the depth of the refrigerator. If this configuration is such that the distance between planes is greater than either the interior height or the interior depth of the UUT, add additional planes and evenly space the middle planes between the leftmost and rightmost plane until the distance between planes is less than either the height or depth of the UUT. At each location, thermocouples shall be placed in the geometric center of each plane and 3 in. ± 1 in. diagonally from each corner of each plane (5 sensors per plane).

a. If the location of any thermocouple interferes with any hardware built into the UUT, move that plane of thermocouples along the length of the UUT until the thermocouples are at least 2 inches away from the hardware.

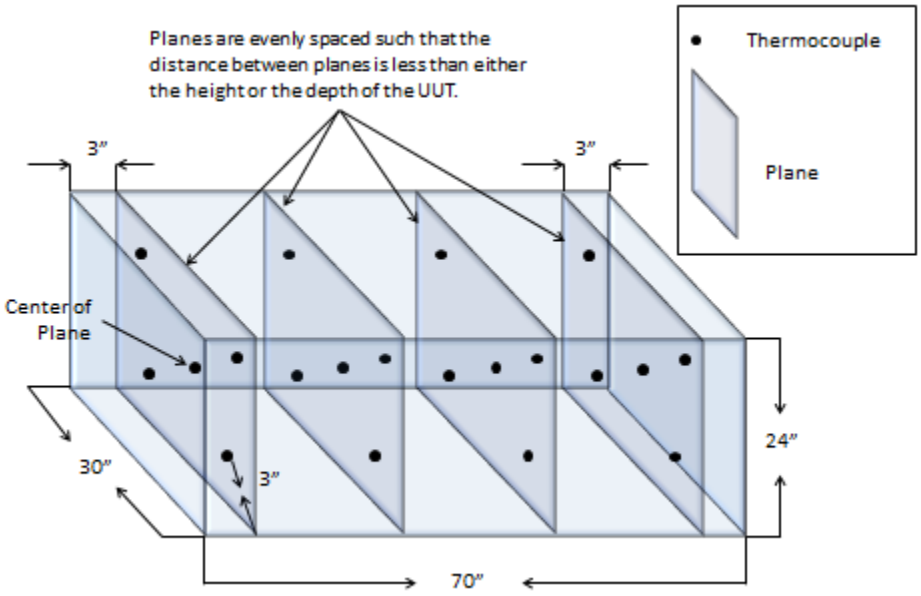

Figure 2: Example of Placement of Thermocouples in Chest Freezer Without Shelves or Baskets

Note: Stakeholders requested clarification regarding the placement of thermocouples inside of a UUT. DOE has updated the thermocouple replacement requirements to account for units with inner doors and chest-type UUTs. DOE is interested in stakeholder feedback regarding the updated thermocouple placement requirements.

6 TEST METHODOLOGY FOR ALL PRODUCTS

6.1 General Principles

A) Measurements:

1) The following data shall be measured and reported at the beginning of the test:

a. Air velocity measured at point T_B.

2) The following data shall be recorded at one-minute intervals during the test:

a. Time: The time elapsed from the beginning of the test. The beginning and end of any Refrigeration and/or Defrost Cycle shall also be noted.

b. Total energy consumption of the UUT.

c. Temperature recorded by each thermocouple in the cabinet.

d. Dry bulb temperature at points T_A and T_B.

e. Wet bulb temperature at points T_A and T_B.

B) Cabinet Temperature Requirements: UUTs shall be tested at the following Cabinet Temperatures, as defined in Section 3, based on product type:

Table 1. Cabinet Temperature Requirements

Product Type	Cabinet Temperature and Acceptable Tolerance (ºC)
Laboratory Grade Refrigerators	4 ± 1
-20 Freezers	-20 ± 1
-30 Freezers	-30 ± 1
-40 Freezers	-40 ± 1
Ultra-Low-Temperature Laboratory Freezers	-70 ± 1.5
	-80 ± 1.5

1) Ultra-Low Temperature Freezers shall be tested at both -70 and -80 °C.

2) Products that are capable of operating at multiple temperatures shall be tested at the lowest temperature listed in Table 1 at which the product is capable of operating.

Note: DOE and EPA are interested in stakeholder feedback regarding whether the Product Types specified in Table 1 appropriately describe all products covered by this Test Method and whether any additional set point temperatures should be considered for each Product Type. DOE and EPA also request feedback regarding any other Product Types that should be included and at what temperatures they should be tested.

In addition, DOE and EPA also request stakeholder feedback regarding whether there are any units that can operate as both a refrigerator and freezer (i.e., a single compartment can be set to temperatures both above and below 0 °C) and how they are operated most often in normal usage.

6.2 Door-Opening Requirements

A) Doors shall be opened as follows:

1) For UUTs with swinging doors: If the UUT does not have inner doors, the main door shall be opened to an angle of 90 degrees ± 1 degree (relative to the closed-door position). If the UUT has inner doors, inner doors shall be opened to an angle of 90 degrees ± 1 degree, and the main door shall be opened to an angle of 90 degrees ± 1 degree or to the smallest angle that will allow inner doors to be opened to an angle of 90 degrees ± 1 degree, whichever is largest.

2) For UUTs with sliding doors: Doors shall be opened as far as possible.

B) For Refrigerators: Each door shall be opened a total of 24 times during the test—three times per hour, every 20 minutes, for eight consecutive hours. The door shall be opened at a constant rate over a period of two seconds, held open for 15 seconds, and closed at a constant rate over a period of two seconds.

C) For Freezers and ULFs: Each door shall be opened a total of eight times during the test—once per hour, every 60 minutes,, for a period of eight consecutive hours..

1) If the UUT has inner doors:

a. Open the main door at a constant rate over a period of 2 seconds.

b. Open the largest inner door. If more than one door is the same size, open the uppermost of those doors (for upright freezers) or the rightmost of the doors (for chest freezers).

c. Leave doors open for 15 seconds.

d. Close inner door at a constant rate over a period of 2 seconds.

e. Close main door at a constant rate over a period of 2 seconds.

2) If the UUT does not have inner doors:

a. Open the main door at a constant rate over a period of two seconds.

b. Leave door open for 15 seconds.

c. Close main door at a constant rate over a period of 2 seconds.

Note: In the Draft 1 Test Method, DOE requested stakeholder feedback regarding the proposed door opening requirements. DOE received some stakeholder comments that agreed with the proposed door openings. Others requested door openings be removed from the Test Method citing concerns regarding the repeatability of any door opening test, as well as the relevance of the proposed door opening requirements to normal operation. Some stakeholders also recommended that units be tested at a higher ambient temperature without door openings, commenting that this would simulate the increased energy consumption caused by door openings.

Based on stakeholder comments, DOE performed additional testing to evaluate the inclusion of door-openings in the test method. For units with no inner doors, DOE performed testing by opening the door once per hour for 15 seconds for eight consecutive hours. For units with inner doors, DOE evaluated two different door-opening patterns. In both patterns, DOE opened the outer door and one inner door once per hour for 15 seconds, beginning with the opening of the inner door, for eight consecutive hours. In the first pattern, DOE opened the largest inner door for all door-openings. In the second pattern, DOE opened either the topmost (for upright units) or rightmost (for chest units) door in the first hour. In each of the next hours, DOE opened the inner door closest to the one opened in the previous hour. DOE also tested with an elevated ambient temperature.

Test results indicated that the power consumption of the unit changed less than 5 percent between Refrigeration Cycles for units without inner doors and for units with inner doors using the first inner door-opening pattern. Results obtained using the second inner door-opening pattern showed fluctuations greater than 5 percent between Refrigeration Cycles. DOE also found that testing in an elevated ambient temperature without door openings did not consistently correlate with testing at the normal ambient temperature with door openings for the units that were tested; thus, DOE does not believe that testing with an elevated ambient temperature can adequately simulate door openings for the range of products covered by this test method. Based on this testing, DOE believes that testing with door-openings using the first inner door-opening method described above produces more consistent test results and has decided to retain the proposed door openings in the Draft 2 Test Method. DOE also believes this to be more representative of normal operation than testing without door openings.

Stakeholders also commented that opening all of the inner doors at one time did not represent normal operation for any product types covered by this Test Method. DOE agrees with the stakeholders' comment and has updated the Draft 2 Test Method to specify that only one inner door shall be opened for each outer door opening. DOE is interested in stakeholder feedback regarding the proposed door-opening requirements. In addition, DOE is requesting stakeholder feedback regarding whether there are any products covered by this Test Method that do not have any doors or for which the proposed door-opening requirements would not be applicable.

6.3 Energy Consumption Test

A) Steady-State Condition: When the test conditions specified in Section 4 of this test method have been achieved, the UUT shall be operated until the UUT reaches and maintains Steady-State Conditions for at least three complete Refrigeration Cycles or, if the unit does not cycle, for at least three hours. Controls may be adjusted as recommended by the manufacturer to obtain Steady-State temperature conditions within the Cabinet Temperature Requirements, specified in Table 1.

B) Test Periods: The test period shall be performed as described below based on the UUT's as-shipped defrost setting. Door openings, as specified in Section 6.2, shall begin three hours after the start of a defrost period, if one occurs. Otherwise they must start at the beginning of the 24-hour period.

1) UUTs with No Defrost, Manual Defrost, or Semi-Automatic Defrost: The test period shall be 24 hours with no defrost.

2) UUTs with Automatic or Variable Defrost: The test period shall be 24 hours starting at the beginning of a defrost period.

3) ULFs: The test period shall be 24 hours.

Note: Upon further evaluation, DOE recognized the additional burden and overall subjectiveness of the Defrost Adequacy Assurance test included in Draft 1 of the test method and does not believe the Defrost Adequacy Assurance test is the appropriate method for determining defrost performance at this time. As such, DOE has removed the defrost adequacy assurance test from the Draft 2 Test Method. DOE requests stakeholder feedback regarding the removal of this test, particularly whether there is a more appropriate and less burdensome method for evaluating the defrost performance of units covered by this Test Method.

7 REPORTING

A) Test Cabinet Temperature: The overall average of all Cabinet Temperatures measured during the 24-hour test period shall be reported.

B) Ambient Temperature: The average dry-bulb and wet-bulb temperatures shall be reported for the entire 24-hour test period.

C) The following values shall be calculated and reported for a three hour period during the test that does not include any of the eight hour door opening periods.

1) Test Uniformity: The overall test Uniformity shall be calculated and reported by taking the average of the Uniformities calculated for each one minute measurement interval.

2) Test Stability: The overall test Stability shall be calculated and reported by taking the average of the Stabilities calculated for each thermocouple.

3) The maximum and minimum measured temperatures and the Peak Variance.

Note: Stakeholders requested that Uniformity and Stability be defined and reported as part of the this Test Method. DOE agrees with stakeholders that these values should be reported and that they provide additional performance information to consumers without increasing test burden. DOE requests stakeholder feedback regarding the inclusion of reporting requirements for Uniformity and Stability.

D) Energy Consumption:

1) For LGRs and LRFs, the total energy consumption measured during the 24-hour test period shall be reported, in kWh/day.

2) For ULFs:

a. The total energy consumption measured during the 24-hour test period at both Cabinet Temperatures (as noted in Table 1) shall be reported.

b. In addition, the calculated energy consumption at -75 °C shall be calculated and reported as the weighted average of the test results at -70 °C and -80 °C, as follows:

$$Energy\ consumption = E1 + (-75 - T1) \times \frac{(E2 - E1)}{(T2 - T1)}$$

Where:

T1 = Overall average of all recorded interior temperature measurements over the course of the test at -70 °C

T2 = Overall average of all recorded interior temperature measurements over the course of the test at -80 °C

E1 = Total energy consumption during the test at -70 °C

E2 = Total energy consumption during the test at -80 °C.

8 REFERENCES

A) AHAM. 2008. AHAM HRF-1-2008, Energy and Internal Volume of Refrigerating Appliances. Washington, DC: Association of Home Appliance Manufacturers.