ENERGY STAR® Program Requirements Product Specification for Laboratory Grade Refrigerators and Freezers and Ultra-Low-Temperature Freezers

Draft 1 Test Method
Rev. Oct-2012

1 OVERVIEW

The U.S. Department of Energy (DOE) developed this ENERGY STAR supplement to American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ANSI/ASHRAE) 72-2005, *Method of Testing Commercial Refrigerators and Freezers*, to document the changes to the test standards as they apply to laboratory grade refrigeration equipment. This test method was developed to provide manufacturers with a meaningful and consistent method for measuring and comparing energy efficiency and performance data for laboratory grade refrigerators and freezers (Lab R/F) and ultra-low-temperature laboratory freezers (ULF), and to ensure that the reporting results are appropriate for end users' information needs.

2 APPLICABILITY

This test method is applicable to Lab R/Fs and ULFs, specifically:

A) Lab R/Fs: general purpose laboratory refrigerators, blood bank refrigerators, pharmacy and chromatography refrigerators, general purpose laboratory freezers, -30ºC freezers, -20ºC freezers;

B) 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) Acronyms:

1) AHAM: Association of Home Appliance Manufacturers
2) ANSI: American National Standards Institute
3) ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers
4) AT: Average Temperature of all Test Simulators
5) CEC: Compressor Energy Consumption
6) CTS: Coldest Test Simulator Temperature
7) CTSA: Coldest Test Simulator Average Temperature
8) DEC: Defrost Energy Consumption
9) DOE: U.S. Department of Energy
10) EPA: U.S. Environmental Protection Agency
11) NIST: National Institute of Standards and Technology
12) TDEC: Total Daily Energy Consumption
13) ULF: Ultra-Low-Temperature Laboratory Freezer
14) UUT: Unit Under Test
15) WTS: Warmest Tests Simulator Temperature
16) WTSA: Warmest Test Simulator Average Temperature

B) AHAM Volume: The interior volume of a refrigerator as calculated by Association of Home Appliance Manufacturers (AHAM) HRF-1-2008, *AHAM Standard Household Refrigerators/Household Freezers*.

C) Automatic Defrost (No-Frost): 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 cooled surfaces. Refrigerated lab specimen temperatures are maintained during operation of the automatic defrost system(s). The defrost water is disposed of automatically.

D) Automatic Smart or On Demand Defrost: A system designed to defer defrost cycles until they are necessary as indicated by the performance of the evaporator coil.

E) Closed Refrigerator: A display or holding refrigerator where specimen is accessible for removal by opening or moving doors or panels.

F) Compressor Energy Consumption (CEC): The energy consumed by the compressor expressed in kilowatt hours (kWh) per day.

G) Condensing Unit: An apparatus for processing low-pressure refrigerant vapor back into high-pressure liquid refrigerant to be used for cooling a refrigerator.

H) Cycle: The period of 24 hours for which the energy use of a refrigerator or freezer is calculated as though the consumer activated compartment temperature controls were set so that the desired compartment temperatures were maintained.

I) Defrost Energy Consumption (DEC): The energy consumed during defrost cycles expressed in kWh per day.

J) Fully Open (For Hinged Doors): Opened to an angle of not less than 75º.

K) Fully Open (For Sliding Doors): Opened as far as they will go.

L) Laboratory Grade Freezer: A refrigerated cabinet used for storing volatile reagents and biological specimens at temperatures between -40ºC and 10ºC (-40ºF and 50ºF), typically marketed through laboratory equipment supply stores for laboratory and medical use.

M) Laboratory Grade Refrigerator: A refrigerated cabinet used for storing non-volatile reagents and biological specimens at temperatures between -5 ºC and 12 ºC (23ºF and 53.6ºF), typically marketed through laboratory equipment supply stores for laboratory or medical use.

N) Load Limit: The maximum space available within the display or storage compartments of the refrigerator usable for lab specimens as specified by the manufacturer, expressed in m^3 (ft^3).

O) Load-Line Volume: The gross interior volume of the refrigerator contained within the load-limit lines. This gross volume is calculated without display devices installed, expressed in m^3 (ft^3).

P) Manual Defrost: A system in which the defrosting of the refrigerated surface is accomplished by natural or manual means with manual initiation and manual termination of the overall defrost operation.

Q) Net Usable Volume: The volume of interior usable space intended for refrigerated storage or display, specifically consisting of the usable interior volume within the claimed load limit boundaries. Any of this volume occupied by evaporator coils, fan grilles, ducts (including any space intentionally made unusable by fences and grilles), or any other significant interior protrusions are excluded from the *net usable volume*. For cases normally equipped with shelves, the front edge of the shelf is assumed to be the front load limit boundary. To be consistent, shelves and other display devices are not treated as significant interior protrusions. The volume occupied by shelves and other display devices is not subtracted from the *net usable volume* expressed in m^3 (ft^3).

R) Open Refrigerator: A display or holding refrigerator where the lab specimen is accessible for removal without opening or moving doors or panels.

S) Refrigerant: Fluid used for heat transfer in a refrigerating system that absorbs heat when the fluid is at a low temperature and low pressure and transfers heat when the fluid is at a high temperature and a high pressure; the transfer usually involves a change of state of the fluid.

T) Representative Shelving: Shelving, which is installed as sold to the end user.

U) Running Cycle: The period of time between the start of refrigeration[1] after a defrost termination and the beginning of the next successive defrost.

V) Secondary Coolant: Liquid used for the transmission of heat without a change of state, having no flash point or having a flash point above 66ºC (150.8ºF).

W) Self-Contained Refrigerator: A refrigerator that has the condensing unit mounted in or on the refrigerator cabinet as opposed to a refrigerator operating on a remote condensing unit.

X) 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. Defrost water is disposed of automatically or collected in a container for subsequent manual removal. A means of accelerating the rate of defrost may or may not be included in the product design. When testing for energy consumption, this is considered a manual Defrost product.

Y) Sensitivity: The relationship between an observed change in the position of an instrument pen, pointer, or indicator, and the magnitude of change in the measured quantity required to produce that reaction of the indicator. It can be expressed as a numerical ratio if the units of measurement of the two quantities are stated. An increase in sensitivity means a corresponding increase in the ability of an instrument to react to extremely small changes in the measured quantity.

Z) Stabilization Period: The total period of time during which Steady-State conditions are being attained or evaluated.

AA) Steady State: The condition where the average temperature of all thermocouples changes less than 0.2ºC (0.4 ºF) from one 24-hour period or refrigeration cycle to the next.

Note: DOE welcomes stakeholder comments on whether the definition for steady state is suitable for all products in scope; specifically, can all products reach the proposed tolerances and is the time period presented appropriate?

BB) Temperature, Dry-Bulb: The temperature of a gas or mixture of gases indicated by an accurate thermometer after correction for radiation.

CC) Temperature, Wet-Bulb: The temperature at which liquid or solid water, by evaporating into air, can bring the air to saturation adiabatically at the same temperature. Wet-bulb temperature (without qualification) is the temperature indicated by a wet-bulb psychrometer constructed and used according to specifications.

DD) Test: A 24-hour performance test conducted under one set of conditions after Steady-State conditions occur as described in this test procedure.

EE) Total Daily Energy Consumption (TDEC): A calculated energy consumption value for self-contained refrigerators and freezers based upon the requirements of this standard expressed in kWh per day.

FF) Transient State: The state in which the system undergoes a normal change in operation, such as thermostat cycling or actuation of a defrost control.

GG) Ultra-Low-Temperature Laboratory Freezer (ULF): A freezer designed for laboratory application that is capable of maintaining storage temperatures between -70°C and -80°C, inclusive.

[1] Refrigeration starts when the compressor turns on.

Note: DOE welcomes comments on all proposed definitions.

4 TEST SETUP

A) Test Conditions:

1) Ambient Conditions:

a) Dry Bulb: The average test-room dry-bulb temperature shall be 24.0ºC ± 1.0ºC (75.2ºF ± 1.8ºF), when measured in accordance with Section 5 of this test procedure. Individual recorded temperatures shall be 24.0ºC ± 2.0ºC (75.2ºF ± 3.6ºF). This measurement point shall be at the geometric center of the vertical plane of the storage opening, 914 mm ± 50 mm (3.0 ft ± 0.2 ft) away from the vertical plane.

b) Wet Bulb: The average test-room wet-bulb temperatures shall be 18.0ºC ± 1.0ºC (64.4ºF ± 1.8ºF), when measured in accordance with Section 5 of this test procedure. Individual recorded temperatures shall be 18.0ºC ± 2.0ºC (64.4ºF ± 3.6ºF). This measurement point shall be at the geometric center of the vertical plane of the storage opening, 914 mm ± 50 mm (3.0 ft ± 0.2 ft) away from the vertical plane.

c) Dry Bulb Gradient: The dry-bulb temperature gradient shall be less than 0.6ºC per 305 mm (1.0ºF per foot) between T_A and T_B as defined in Section 5 of this test procedure.

d) Air Currents: Test-room air currents across the display opening shall not exceed 0.5 m/s (45 ft/min). Any air movement shall be parallel to the plane of the opening. No external air drafts shall blow directly into the refrigerated zone.

e) Lighting: Test-room lighting shall be fluorescent with illumination of at least 800 lux (74.4 foot-candles), when measured vertically at 300 mm (11.8 in.) from the geometric center of the door opening. This measurement shall be made prior to the test and the standard fixture lamps shall be on.

f) Radiant Heat: In order to maintain a standard level of radiant heat, the test room shall be arranged so that the display or storage area faces only white gloss-finished surfaces having an average temperature not less than 21.2ºC (70.0 ºF) and positioned no closer than 1500 mm (59.1 in.) from the extremities of the refrigerator itself. Suspended panels may be used.

Note: The proposed Ambient Conditions are consistent with those in ASHRAE 72-2005. DOE requests stakeholder comment on the proposed requirements for dry and wet bulb temperatures, dry bulb gradient temperature, air currnets, room lighting and radiant heat. accessory setup, test room ambient temperatures and test room illumination.

DOE is particularly interested in receiving comment on the necessity of the Lighting and Radiant Heat requirements for lab R/Fs and ULFs.

2) Instrumentation Specifications:

a) Calibration: Instruments shall be of the types and have the accuracies listed below and shall be calibrated annually. All calibrations must adhere to the National Institute of Standards and Technology (NIST) standards.

b) Temperature Measuring Instruments: Accuracy of temperature measurements shall be within ± 0.8ºC (± 1.4 ºF). Accuracy of temperature-difference measurements shall be within ± 0.1ºC (± 0.2 ºF).

c) Other Instruments: The accuracies of other instruments shall be as follows:

i) Time measurements shall be made with an accuracy of ± 0.5% of the time period being measured;
ii) Illumination measurements shall be made with an instrument having an accuracy of ± 10%;
iii) Air velocity measurements shall be made with an instrument having an accuracy of ± 10%; and
iv) Electrical energy measurements shall be made with instruments accurate to ± 2% of the quantity measured.

Note: DOE seeks stakeholder comment on the proposed instrument specifications.

5 PRE-TEST CONFIGURATION

A) General Configuration

1) Test Set-Up: The cabinet with its refrigerating mechanism shall be assembled and set up as nearly as practical 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:
   a) Shelves and door bins shall be evenly spaced throughout the compartment, unless otherwise specified in the manufacturer's instructions;
   b) Compartments, which are convertible (e.g., from refrigerator to freezer), are operated in the highest energy usage position;
   c) Any refrigerator operational mode, which reduces energy usage during energy consumption testing and not during normal usage, shall be disabled for energy consumption testing.

Note: DOE believes that the proposed test set-up requirements are sufficiently broad to encompass all types of lab R/Fs and ULFs. DOE is interested in stakeholder comment on the applicability of the proposed test set-up requirements for both lab R/Fs and ULFs. If there are specific differences, DOE requests stakeholders to provide that information.

2) Test Room Conditions: The UUT shall be installed within the controlled test room in accordance with the following:
   a) 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.
   b) Ambient Temperatures: The ambient wet-bulb and dry-bulb temperatures shall be measured at two locations along a vertical line at the centerline of the refrigerator. These points are related to the highest point where room air contacts refrigerated air. The ambient measurement line extends from a point, which is 150 mm ± 50 mm (5.9 in. ± 2 in.) above the highest point on the refrigerator, down to the geometric center of the door opening. Both points are located 915 mm ± 15 mm (36 in. ± 2 in.) out from the door opening. These points shall be selected such that they are not affected by external or UUT heat sources, such as ballasts, heaters, or lights. It shall be verified that no location around the perimeter of the UUT at the same height as those points has an average temperature lower than that specified for the test conditions.

c) Illumination: During the temperature test period, the room light shall be maintained as outlined in Section 4A)1)e).

3) Power Supply: Unless otherwise specified, the electrical power supply shall be 115 ± 1 V, 60 Hertz (Hz) at the product service connection. The actual voltage shall be recorded as measured at the product service connection with the compressor motor operating.

4) Loading of Un-Weighted Bare Thermocouples: The UUT shall be filled with un-weighted bare thermocouples as follows:

a) Un-Weighted Bare Thermocouple Locations (UUTs with Shelves): Representative shelving should 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. Shelves should be placed in the (1) top allowable position, (2) geometric center, and (3) lowest allowable position. Thermocouples shall be placed on three planes located one inch above each shelf or one inch above the bottom drawer or basket. Thermocouples shall be placed in the geometric center and three inches diagonally from each corner of each shelf (5 sensors per shelf). For adjacent shelves within a UUT, thermocouples shall be placed at each shelf standard break between adjacent shelves. For adjacent baskets within a UUT, thermocouples shall be placed at the geometric center of each basket.

Note: In the ENERGY STAR supplement to ANSI/ASHRAE 72-2005, thermocouple placement is clearly defined for shelves (including adjacent shelves), drawers, and units with a single basket. Thermocouple placement is not well defined for units with multiple, adjacent baskets (i.e., in chest freezers).

DOE recommends placing thermocouples at the geometric center of each basket. This will result in approximately five total thermocouples (dependent on the number of baskets), which is consistent with the number of thermocouples per non-adjacent shelf/basket. Additionally, it is consistent with the placement of thermocouples at the geometric center of each non-adjacent shelf/basket.

DOE welcomes stakeholder comments on this approach.

b) Un-Weighted Bare Thermocouple Locations (UUTs without Shelves): If a UUT is sold without shelving, then the lab may test it without shelves. If the UUT is sold without shelves but then offers different shelf types for installation in the field, then the lab shall test each of those options. Thermocouples shall be located in planes three inches from the left end, three inches from the right end, and at intervals of no more than 610 mm (24 inches) across the width of the refrigerator. At each location, thermocouples shall be placed in the geometric center of each plane and three inches diagonally from each corner of each plane (5 sensors per plane).

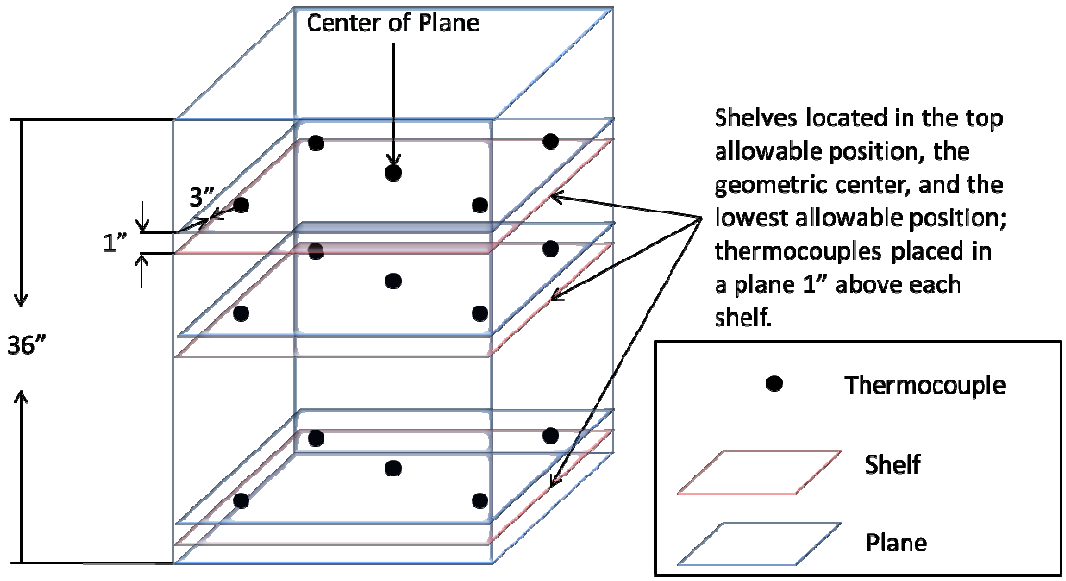

Figure 1: Example of Placement of Thermocouples in Upright Freezer with Shelves

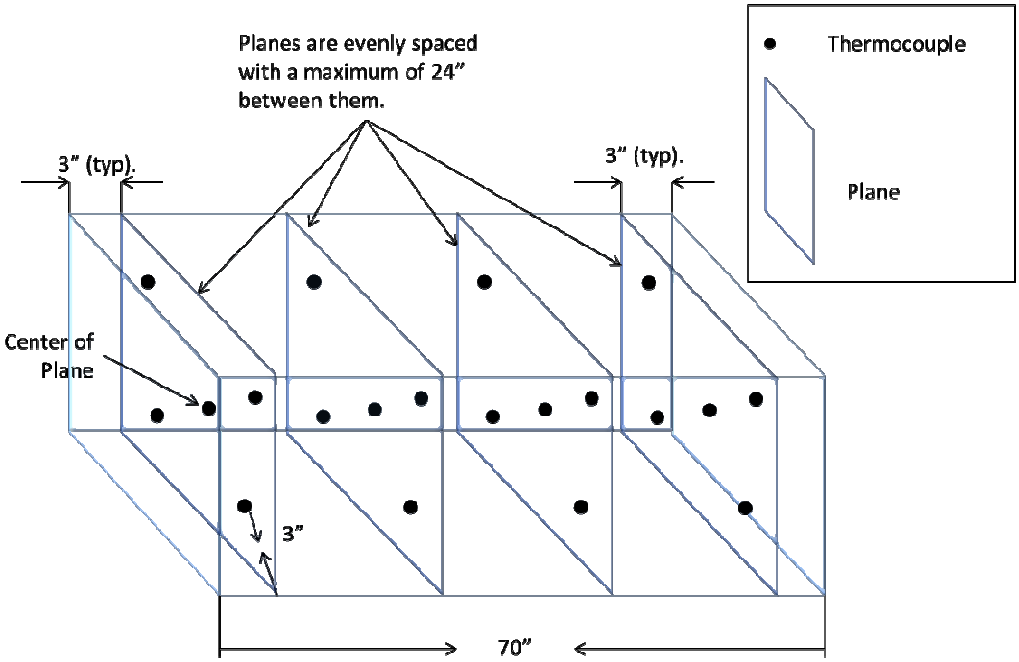

Figure 2: Example of Placement of Thermocouples in Chest Freezer Without Shelves or Baskets

Note: DOE is proposing to use the same thermocouple placement for ULFs, and assumes that most upright ULFs are sold with shelves and would use the configuration shown in Figure 1, while most chest ULFs do not have shelves or baskets and would use the configuration shown in Figure 2.

DOE welcomes stakeholder comments on whether this thermocouple placement is appropriate for ULFs. If the proposed thermocouple placement is not appropriate, DOE welcomes stakeholder comments on what would be appropriate.

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

6 TEST METHODOLOGY FOR ALL PRODUCTS

6.1 General Principles:

A) Steady-State Condition: A steady-state condition, as defined in Section 3 of this test procedure, shall be established for the test, and data shall then be recorded.

B) Ambient Conditions: The ambient conditions for the test shall be recorded and averaged to verify that the requirements are as specified in Section 4 of this test procedure. The interval between recordings shall not exceed three minutes.

6.2 Door-Opening Requirements:

A) Each door shall be opened using evenly-spaced time intervals.

B) For Refrigerators: Each door shall be opened for fifteen seconds, three times per hour, for eight consecutive hours.

C) For Freezers: Each door shall be opened for fifteen seconds, once per hour, for 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 to an angle of 90 degrees.
   b) Open all inner doors at once, at a constant rate, over a period of 2 seconds, to an angle of 90 degrees.
   c) Leave doors open for 7 seconds.
   d) Close all inner doors 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 to an angle of 90 degrees.
   b) Leave door open for 11 seconds.
   c) Close main door at a constant rate over a period of 2 seconds.

Note: DOE requests comment on the proposed door opening requirements. In particular, DOE requests feedback on the proposed approach for testing products with and without inner doors.

DOE also requests stakeholder feedback on the impact of multiple door openings on the repeatability and reproducibility of the test method. Repeatability and reproducibility may be improved by testing products with no door openings and increasing the test chamber ambient temperature to simulate the power necessary to cool the inner compartment to the set temperature if doors were opened on a regular schedule.

DOE notes that door openings are used to test Commercial Refrigeration Equipment (CRE) (10 CFR 431 Subpart C2). However, DOE believes that Lab R/F and ULFs may have significantly fewer door openings per day than CRE. DOE is interested in receiving information from stakeholders on the typical number of door openings for Lab R/Fs and ULFs.

6.3 Defrost:

A) The test shall begin with a defrost period.

1) Manual: Test period must be 24 hours with no defrost cycle.
2) Automatic Timed: Test period must be at least 24 hours with a minimum of two defrost cycles.
3) Automatic Smart or On Demand: Test period must be at least 24 hours with a minimum of one defrost cycle (including pull down). If test period extends beyond 24 hours to capture a defrost cycle, lab shall derive energy consumption per day (kWh per day) by dividing total test duration (in hours) by 24.

Note: DOE requests comment on the proposed defrost conditions.

DOE understands that ULFs do not have automatic defrost and has therefore assumed that these products would be subject to the Manual defrost requirement.

6.4 Stabilization Period:

A) When test conditions, specified in Section 4 of this test method, have been achieved, the UUT shall be pre-cooled and operated until steady-state conditions occur. Self-contained UUTs shall have the controls adjusted to obtain the desired performance. During the pre-cooling period, controls shall be adjusted to obtain steady-state temperature conditions within the settings as recommended by the manufacturer. After the temperatures have stabilized so that steady-state conditions exist, the UUT shall continue to operate for a period of at least 12 hours without any adjustment to the controls.

6.5 Volume Measurements:

A) Tolerances: The refrigerator (or refrigerator compartment) and freezer (or freezer compartment) volume is to be recorded to the nearest 0.1 L (0.01 ft^3).

B) Determination of Volume: The volume shall take into account the exact shapes of the walls including all depressions or projections. When the volume is determined, internal fittings such as shelves, removable partitions, containers, and interior light housing shall be considered as not being in place. The items below shall be considered as being in place and their volumes deducted:

1) The volume of control housings;
2) The volume of the evaporator space (if located in the refrigerated cabinet);
3) The volume of air ducts required for proper cooling and operation of the unit (if present in the refrigerated cabinet); and

2 http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title10/10cfr431_main_02.tpl

4) Space occupied by shelves molded into the inner door panel.

Note: DOE is considering allowing manufacturers to estimate volume based on Computer Aided Design (CAD) drawings. In the event that a manufacturer uses a CAD drawing rather than physically measuring the unit, the manufacturer must submit the CAD drawing to the Certification Body (CB) at time of qualification.

DOE seeks stakeholder comment on the accuracy of CAD drawings compared to physical measurement. DOE also requests feedback on the feasibility of supplying CBs with CAD drawing/files specific to the model to be qualified.

C) Volume of Evaporator Space: If the evaporator is located in the refrigerated cabinet, the volume of the evaporator space shall be the product of the depth, width, and height. The total volume to be deducted shall comprise the following:

1) Forced Air Evaporator: The total volume of and behind the evaporator cover, including volume occupied by the evaporator fan and the fan scroll.
2) Plate Style (or Roll-Bond) Evaporators: The volume behind vertically installed plate style evaporators and the volume above horizontally installed plate style evaporators, if the distance between the horizontal plate style evaporator and the nearest above linear surface is less than 50 mm (2 in.). Removable drip trays/troughs shall be considered as not present.
3) Refrigerant Filled Shelving: The volume above the uppermost shelf and below the lowermost shelf, if the distance between the shelf and the nearest horizontal plane of the cabinet inner wall is less than 50 mm (2 in.). All other refrigerated shelves are considered as not present.

6.6 Energy Consumption:

A) Time and Cycles: The overall time from start to end of the test, as well as the time period for each running cycle, shall be measured and recorded.

B) Thermocouple Temperature Measurement: After steady-state conditions occur, the test simulator temperatures and all other data shall be recorded at three-minute intervals beginning at the start of the defrost period, through the defrost period, and through the running cycle until the beginning of the next successive defrost period. After this test period, all test simulators shall continue to be recorded throughout the 24-hour refrigerant flow period to ensure that no changes occur that would change the test results.

C) Temperature Uniformity Test: Temperature measurements shall be taken during the energy consumption test during two three-hour periods while the door is closed at three-minute intervals:

1) Lab must collect temperature uniformity data during two three-hour periods: one that includes a defrost cycle and one in steady-state (i.e., no defrost cycle) AND
2) Lab must report stability for the central thermocouple on each shelf (average temperature and ± range).

D) Defrost Adequacy Assurance: For UUTs with either Automatic Times or Automatic Smart/On Demand defrost, the test shall verify that any defrost setting and arrangement is adequate to melt all frost and ice from coils and flues and drain it out of the UUT. This shall be checked each time any adjustment is made to the defrost setting. At the conclusion of the test, the UUTs, employing a particular defrost setting, shall continue to operate at the same stabilized conditions for a period of not less than two additional running cycles, or 24 hours, whichever comes first. After this period and while the UUT is within the same stabilized operating temperature range and during the latter half of the running cycle, all drain pans, fans, coils, ducts, flues, and other areas shall be checked for any residual ice or frost that might continue to accumulate, resulting in ice buildup in flues, drain pans, and coils over a period of time. If ice or frost is found, then an additional 48-hour running period shall be performed while still maintaining the performance test with no control changes. At the conclusion of this additional 48-hour period, another examination shall be made as described above. If the ice or frost accumulation has stabilized and not increased, then test data are acceptable. If the ice or frost buildup has increased, then that test is unacceptable for inclusion in the test performance data and this occurrence shall be reported.

7 REPORTING METHOD

A) Standard Deviation: Labs shall report both the standard deviation (S_N) and minimum/maximum temperatures collected for each thermocouple during the test period, using the standard deviation formula below, and multiply the results by three to obtain three standard deviations of the average of all interval standard deviations.

$$S_N = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

Where:

N = number of data points

$\bar{x}$ = average of all data points

x_i = data for individual data point at any particular time

B) Set-Point Temperature Requirements:

Table 1. Set-Point Temperature Requirements

Product Type	Set-Point Temperature (ºC)	Average of All Thermocouples During Entire Test Period (ºC)
General Purpose Laboratory Refrigerators	4	4 ± 1
Blood Bank Refrigerators	4	4 ± 1
Pharmacy and Chromatography Refrigerators	4	4 ± 1
General Purpose Laboratory Freezers	-20	-20 ± 1
-30 Freezers	-30	-30 ± 1
-20 Freezers	-20	-20 ± 1
Ultra-Low-Temperature Laboratory Freezers	-70	-70 ± 1.5
	-80	-80 ± 1.5

Note: The set-point temperature is not defined for laboratory grade freezers with minimum temperatures not equal to -30ºC or -20ºC.

DOE recommends using a set-point temperature of -30ºC for units whose minimum temperature is -30ºC or below and a set-point temperature of -20ºC for units whose minimum temperature falls between -29ºC and -20ºC.

The minimum set-point temperature will be determined by the unit's intended end use. For example, certain cell cultures tend to be stored at lower temperatures than vaccines and will therefore require a freezer classified at a lower temperature.

DOE recommends testing ULFs at two set-point temperatures: -70ºC and -80ºC, and calculating a weighted average of the energy results.

DOE welcomes stakeholder comments on this approach.

8 REFERENCES

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

B) AHRI. 2006. AHRI Standard 1200-2010, Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets. Arlington, VA: Air-Conditioning and Refrigeration Institute.

C) ASHRAE. 2005. ANSI/ASHRAE Standard 72-2005, Method of Testing Commercial Refrigerators and Freezers. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

D) ASHRAE. 2006. ANSI/ASHRAE Standard 41.1-1986 (RA 2006), Standard Method for Temperature Measurement. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.