



ENERGY STAR® Program Requirements for Laboratory Grade Refrigerators and Freezers

Partner Commitments

Following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacture and labeling of ENERGY STAR certified products. The ENERGY STAR Partner must adhere to the following partner commitments:

Certifying Products

1. Comply with current ENERGY STAR Eligibility Criteria, which define performance requirements and test procedures for laboratory grade refrigerators and freezers. A list of eligible products and their corresponding Eligibility Criteria can be found at www.energystar.gov/specifications.
2. Prior to associating the ENERGY STAR name or mark with any product, obtain written certification of ENERGY STAR certification from a Certification Body recognized by EPA for laboratory grade refrigerators and freezers. As part of this certification process, products must be tested in a laboratory recognized by EPA to perform laboratory grade refrigerator and freezer testing. A list of EPA-recognized laboratories and certification bodies can be found at www.energystar.gov/testingandverification.

Using the ENERGY STAR Name and Marks

3. Comply with current ENERGY STAR Identity Guidelines, which define how the ENERGY STAR name and marks may be used. Partner is responsible for adhering to these guidelines and ensuring that its authorized representatives, such as advertising agencies, dealers, and distributors, are also in compliance. The ENERGY STAR Identity Guidelines are available at www.energystar.gov/logouse.
4. Use the ENERGY STAR name and marks only in association with certified products. Partner may not refer to itself as an ENERGY STAR Partner unless at least one product is certified and offered for sale in the U.S. and/or ENERGY STAR partner countries.
5. Provide clear and consistent labeling of ENERGY STAR certified laboratory grade refrigerators and freezers. The ENERGY STAR mark must be clearly displayed on the front of the product, on the product packaging, in product literature (i.e., user manuals, spec sheets, etc.), and on the manufacturer's Internet site where information about ENERGY STAR certified models is displayed.

Verifying Ongoing Product Certification

6. Participate in third-party verification testing through a Certification Body recognized by EPA for laboratory grade refrigerators and freezers providing full cooperation and timely responses, EPA/DOE may also, at its discretion, conduct tests on products that are referred to as ENERGY STAR certified. These products may be obtained on the open market, or voluntarily supplied by Partner at the government's request.

Providing Information to EPA

7. Provide unit shipment data or other market indicators to EPA annually to assist with creation of ENERGY STAR market penetration estimates, as follows:

- 7.1. Partner must submit the total number of ENERGY STAR certified laboratory grade refrigerator and freezer products shipped in the calendar year or an equivalent measurement as agreed to in advance by EPA and Partner. Partner shall exclude shipments to organizations that rebrand and resell the shipments (unaffiliated private labelers).
- 7.2. Partner must provide unit shipment data segmented by meaningful product characteristics (e.g., type, capacity, presence of additional functions) as prescribed by EPA.
- 7.3. Partner must submit unit shipment data for each calendar year to EPA or an EPA-authorized third party, preferably in electronic format, no later than March 1 of the following year.

Submitted unit shipment data will be used by EPA only for program evaluation purposes and will be closely controlled. If requested under the Freedom of Information Act (FOIA), EPA will argue that the data is exempt. Any information used will be masked by EPA so as to protect the confidentiality of the Partner.

8. Report to EPA any attempts by recognized laboratories or Certification Bodies (CBs) to influence testing or certification results or to engage in discriminatory practices.
9. Notify EPA of a change in the designated responsible party or contacts within 30 days using the My ENERGY STAR Account tool (MESA) available at www.energystar.gov/mesa.

Performance for Special Distinction

In order to receive additional recognition and/or support from EPA for its efforts within the Partnership, the ENERGY STAR Partner may consider the following voluntary measures, and should keep EPA informed on the progress of these efforts:

- Provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase availability of ENERGY STAR certified products, and to promote awareness of ENERGY STAR and its message.
- Consider energy efficiency improvements in company facilities and pursue benchmarking buildings through the ENERGY STAR Buildings program.
- Purchase ENERGY STAR certified products. Revise the company purchasing or procurement specifications to include ENERGY STAR. Provide procurement officials' contact information to EPA for periodic updates and coordination. Circulate general ENERGY STAR certified product information to employees for use when purchasing products for their homes.
- Feature the ENERGY STAR mark(s) on Partner website and other promotional materials. If information concerning ENERGY STAR is provided on the Partner website as specified by the ENERGY STAR Web Linking Policy (available in the Partner Resources section of the ENERGY STAR website), EPA may provide links where appropriate to the Partner website.
- Ensure the power management feature is enabled on all ENERGY STAR certified displays and computers in use in company facilities, particularly upon installation and after service is performed.
- Provide general information about the ENERGY STAR program to employees whose jobs are relevant to the development, marketing, sales, and service of current ENERGY STAR certified products.
- Provide a simple plan to EPA outlining specific measures Partner plans to undertake beyond the program requirements listed above. By doing so, EPA may be able to coordinate, and communicate Partner's activities, provide an EPA representative, or include news about the event in the ENERGY STAR newsletter, on the ENERGY STAR website, etc. The plan may be as simple as providing a list of planned activities or milestones of which Partner would like EPA to be aware. For example, activities may include: (1) increasing the availability of ENERGY STAR certified products by converting the entire product line within two years to meet ENERGY STAR guidelines; (2) demonstrating the economic and environmental benefits of energy efficiency through special in-store displays twice a year; (3) providing information to users (via the website and user's manual) about

energy-saving features and operating characteristics of ENERGY STAR certified products; and (4) building awareness of the ENERGY STAR Partnership and brand identity by collaborating with EPA on one print advertorial and one live press event.

- Join EPA's SmartWay Transport Partnership to improve the environmental performance of the company's shipping operations. The SmartWay Transport Partnership works with freight carriers, shippers, and other stakeholders in the goods movement industry to reduce fuel consumption, greenhouse gases, and air pollution. For more information on SmartWay, visit www.epa.gov/smartway.
- Join EPA's Green Power Partnership. EPA's Green Power Partnership encourages organizations to buy green power as a way to reduce the environmental impacts associated with traditional fossil fuel-based electricity use. The partnership includes a diverse set of organizations including Fortune 500 companies, small and medium businesses, government institutions as well as a growing number of colleges and universities. For more information on Green Power, visit www.epa.gov/greenpower



ENERGY STAR[®] Program Requirements

Product Specification for Laboratory Grade Refrigerators and Freezers

Eligibility Criteria

Version 1.1

Following is the Version 1.1 ENERGY STAR product specification for Laboratory Grade Refrigerators and Freezers. A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

1 DEFINITIONS

A) Product Types:

- 1) Laboratory Grade Refrigerator (LGR): A refrigeration cabinet used for storing non-volatile reagents and biological specimens at set point 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.
 - a) High Performance: A laboratory grade refrigerator product that is designed to support a maximum peak variation in temperature no greater than 6 °C.
 - b) General Purpose: A laboratory grade refrigerator product that cannot support a maximum peak variation in temperature equal to or less than 6 °C.
- 2) Laboratory Grade Freezer (LGF): A refrigeration cabinet used for storing volatile reagents and biological specimens at set point temperatures between -40 °C and 0 °C (-40 °F and 32 °F), typically marketed through laboratory equipment supply stores for laboratory or medical use.
 - a) High Performance: A laboratory grade freezer product that is designed to support a maximum peak variation in temperature no greater than 10 °C.
 - b) General Purpose: A laboratory grade freezer product that cannot support a maximum peak variation in temperature equal to or less than 10 °C.
- 3) Ultra-Low-Temperature Laboratory Grade Freezer (ULT): A freezer designed for laboratory application that is capable of maintaining set point storage temperatures between -70 °C and -80 °C (-94 °F and -112 °F).
- 4) Combination Laboratory Grade Refrigerator/Freezer: A product composed of two or more refrigerated cabinets, one of which meets the definition of Laboratory Grade Refrigerator and another that meets the definition of Laboratory Grade Freezer.
- 5) Portable Laboratory Grade Refrigerator/Freezer: A refrigerated cabinet used for transporting perishable samples or products, and includes an integral battery or DC power cable to power the refrigeration process when disconnected from AC mains.
- 6) Walk-in Laboratory Grade Refrigerator: A larger laboratory grade refrigerator that is either built-in or composed of prefabricated sectional walk-in units.
- 7) Explosion Proof Refrigerator/Freezer: A product that is composed of a refrigerated cabinet that prevents arcing both inside and outside the cabinet and is typically used when flammable vapors are present, resulting in an explosive atmosphere during standard operation.

- 8) Incubators: A product used to control temperature and humidity often to support growing bacterial cultures or providing suitable conditions for chemical and biological reactions.

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 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.

C) Additional Terms:

- 1) AHAM Volume (V): The interior volume of the refrigerator or freezer as calculated by ANSI/AHAM HRF-1-2008.
- 2) Cabinet Temperature: The average of all temperature measurements taken inside a product's cabinet at any given time.
- 3) Peak Variance: The difference between the maximum and minimum temperatures measured across all temperature measurement devices (TMD) over the course of a given measurement period.
- 4) Refrigeration Cycle: The period of time starting when a unit's refrigeration system turns on, through the time it turns off, and ending when the refrigeration system turns on again.
- 5) Stability: The difference between the maximum and minimum temperature measured by an individual TMD over the course of the entire test period.
- 6) Test: A 24-hour period over which measurements are taken and energy use evaluated under one set of conditions after the pull down period occurs as described in this test procedure.
- 7) Uniformity: The difference between the maximum and minimum temperature measured inside of a unit's cabinet at any given time.
- 8) Solid Door: Less than 75% of the front surface area of the door is glass.
- 9) Glass Door: Greater than, or equal to, 75% of the front surface area of the door is glass.
- 10) Solid Door Cabinet: A laboratory grade refrigerator or freezer in which all outer doors on all sides of the unit are solid doors. These doors may be sliding or hinged.
- 11) Glass Door Cabinet: A laboratory grade refrigerator or freezer in which all outer doors on at least one side of the unit are glass doors. These doors may be sliding or hinged.
- 12) Mixed Solid/Glass Door Cabinet: A laboratory grade refrigerator or freezer in which all outer doors on at least one side of the unit are a combination of solid and glass doors. A unit which has all glass doors on one side and a combination of solid and glass doors on another is considered a mixed solid/glass door cabinet.

D) Referenced Standards Organizations:

- 1) AHAM: Association of Home Appliance Manufacturers
- 2) ANSI: American National Standards Institute

- E) Product Family: A group of product models that are (1) made by the same manufacturer, (2) have the same measured interior volume, (3) the same number of external doors and (3) of the same basic engineering design. Product models within a family can differ in the following characteristics:
- 1) Configurability Characteristics: Characteristics such as internal ports and access holes, drawer and shelf configuration, and other optional accessories.
 - 2) Aesthetic Characteristics: Characteristics such as external finish, color, or door opening orientation (left-opening versus right-opening).

2 SCOPE

2.1 Included Products

- 2.1.1 Products that meet the definitions LGR, LGF, and ULT above are eligible for ENERGY STAR certification. This may include refrigerators and freezers that operate without a compressor.

2.2 Excluded Products

- 2.2.1 Products that are covered under other ENERGY STAR product specifications are not eligible for qualification under this specification. The list of specifications currently in effect can be found at www.energystar.gov/specifications.
- 2.2.2 The following products are not eligible for certification under this specification:
- i. Products that meet the definitions 1.A.4 through 1.A.7 above; and
 - ii. Products which meet the incubator definition above, are marketed as incubators, or are capable of temperature control above 15 °C.

3 CERTIFICATION CRITERIA

3.1 Significant Digits and Rounding

- 3.1.1 All calculations shall be carried out with actual measured (unrounded) values. Only the final result of a calculation shall be rounded.
- 3.1.2 Unless otherwise specified in this specification, compliance with specification limits shall be evaluated exact values without any benefit from rounding.
- 3.1.3 Directly measured or calculated values that are submitted for reporting on the ENERGY STAR website shall be rounded to the nearest significant digit as expressed in the corresponding specification limit.

3.2 Energy Efficiency Requirements

- 3.2.1 Maximum Daily Energy Consumption Requirements: The maximum daily energy consumption (MDEC), in kilowatt-hours per 24 hour period (or kilowatt-hours per 24 hour period per cubic foot for ULTs), shall be less than or equal to that specified below:

Table 1: Maximum Daily Energy Consumption (MDEC) Requirements (kWh/day) for ENERGY STAR Certified Laboratory Grade Refrigerators	
Product Volume (in cubic feet)	Refrigerator
<i>General Purpose</i>	
$0 < V < 25$	$\leq 0.124 V + 2.0$
$25 \leq V$	$\leq 0.121 V + 2.07$
<i>High Performance</i>	
$0 < V < 25$	$\leq 0.184 V + 3.5$
$25 \leq V < 44$	$\leq 0.153 V + 4.28$
$44 \leq V$	$\leq 0.125 V + 5.5$

Note: V = AHAM volume, as defined in Section 1, in cubic feet (ft³).

Table 2: Maximum Daily Energy Consumption (MDEC) Requirements (kWh/day) for ENERGY STAR Certified Laboratory Grade Freezers	
Product Volume (in cubic feet)	Freezer
<i>General Purpose</i>	
$0 < V < 15$	$\leq 0.033 V + 2.0$
$15 \leq V < 30$	$\leq 0.05 V + 1.75$
$30 \leq V$	$\leq 0.188 V - 2.375$
<i>High Performance</i>	
$0 < V < 22$	$\leq 0.09 V + 10$
$22 \leq V$	$\leq 0.426 V + 2.63$

Note: V = AHAM volume, as defined in Section 1, in cubic feet (ft³).

Table 3: Maximum Daily Energy Consumption (MDEC) Requirements (kWh/day/ft³) for ENERGY STAR Certified Ultra-Low Temperature Freezers @ -75 °C

0.55

Note: MDEC for ULTs is based on volume normalized energy consumption at -75 °C as calculated in Equation 1 (ULT Energy Consumption Calculation) in the ENERGY STAR Test Method for Laboratory Grade Refrigerators, Freezers, and Ultra-Low Temperature Freezers.

4 TESTING

4.1 Test Methods

4.1.1 Test method identified in Table 4 shall be used to determine certification to ENERGY STAR.

Table 4: Test Methods for ENERGY STAR Certification

Product Type	Test Method
All	ENERGY STAR Test Method for Laboratory Grade Refrigerators, Freezers, and Ultra-Low Temperature Freezers

4.2 Number of Units Required for Testing

4.2.1 Representative Models shall be selected for testing per the following requirements:

- i. For certification of an individual product model, the Representative Model shall be equivalent to that which is intended to be marketed and labeled as ENERGY STAR.
- ii. For certification of a Product Family, highest energy consuming unit within that Product Family can be tested and serve as the Representative Model. Any subsequent testing failures (e.g., as part of verification testing) of any model in the family will have implications for all models in the family.

4.2.2 A single unit of each Representative Model shall be selected for testing.

4.3 International Market Certification

4.3.1 Products shall be tested for certification at the relevant input voltage/frequency combination for each market in which they will be sold and promoted as ENERGY STAR.

5 EFFECTIVE DATE

5.1.1 Effective Date: The ENERGY STAR Laboratory Grade Refrigerators and Freezers specification shall take effect on **December 21 2016**. To certify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on the model's date of manufacture. The date of manufacture is specific to each unit and is the date on which a unit is considered to be completely assembled.

- 5.1.2 Future Specification Revisions: EPA reserves the right to change this specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through stakeholder discussions. In the event of a specification revision, please note that the ENERGY STAR certification is not automatically granted for the life of a product model. EPA will consider the following in upcoming revisions.
- i. **Temperature Set Point for Freezers**: EPA will investigate whether it is appropriate to set separate requirements in Version 2.0 for freezers designed to operate at -20 °C, -30 °C, and -40 °C, as additional available data allows.
 - ii. **Solid vs. Transparent Doors for Refrigerators**: While EPA's current data set does not show a significant difference in energy efficiency of the two, based on stakeholder feedback EPA will revisit this potential area of differentiation in Version 2.0 as additional available data allows.



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

Final Test Method

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 (ULT).

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 ULTs as established in the ENERGY STAR Eligibility Criteria.

This test method is not applicable to portable laboratory refrigerators and freezers, explosion proof refrigerators and freezers, chromatography refrigerators and freezers, and walk-in laboratory refrigerators and freezers.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR eligibility criteria for laboratory grade refrigerators and freezers.

A) Additional Terms:

- 1) Cabinet Temperature: The average of all temperature measurements taken inside a product's cabinet at any given time.
- 2) Defrost terms:
 - a) 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 removed using a means that requires no user action (e.g., built-in drainage or natural evaporation).
 - b) Manual Defrost: A system in which the defrost cycle is initiated and terminated manually by the user.
 - c) Semi-Automatic Defrost: A system in which the defrost cycle is manually initiated and automatically terminated, with automatic resumption of the normal refrigeration cycle at the conclusion of the defrost operation.
- 3) Peak Variance: The difference between the maximum and minimum temperatures measured across all temperature measurement devices (TMD) over the course of a given measurement period.
- 4) Refrigeration Cycle: The period of time starting when a unit's refrigeration system turns on, through the time it turns off, and ending when the refrigeration system turns on again.

- 5) Stability: The difference between the maximum and minimum temperature measured by an individual TMD over the course of the entire test period.
- 6) Test: A 24-hour period over which measurements are taken and energy use evaluated under one set of conditions after the pull down period occurs as described in this test procedure.
- 7) Uniformity: The difference between the maximum and minimum temperature measured inside of a unit's cabinet at any given time.

B) 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) TMD: Temperature Measurement Device
- 7) ULT: Ultra-Low Temperature Laboratory Freezer
- 8) 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. For units rated to operate at multiple voltages, test the unit at the lowest voltage included in the rating. The actual voltage and power factor shall be measured and reported 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 $24.0\text{ }^{\circ}\text{C} \pm 1.0\text{ }^{\circ}\text{C}$ ($75.2\text{ }^{\circ}\text{F} \pm 1.8\text{ }^{\circ}\text{F}$), when measured in accordance with Section 5 of this test procedure.
- 2) Wet-bulb Temperature: The test-room wet-bulb temperature shall be $18.0\text{ }^{\circ}\text{C} \pm 1.0\text{ }^{\circ}\text{C}$ ($64.4\text{ }^{\circ}\text{F} \pm 1.8\text{ }^{\circ}\text{F}$), when measured in accordance with Section 5 of this test procedure.
- 3) Dry-bulb Temperature Gradient: The dry-bulb temperature gradient shall be less than $2.0\text{ }^{\circ}\text{C}$ per m ($1.0\text{ }^{\circ}\text{F}$ per foot) from 2 inches above the floor or supporting platform to a height 30.5 cm (1.0 ft) above the top of the cabinet.
- 4) Air Currents: Test room air currents across the door opening shall not exceed 0.25 meters per second (49 feet per minute) as measured at T_B . No external air drafts shall blow directly into the refrigerated zone.

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 $\pm 0.8\text{ }^{\circ}\text{C}$ ($\pm 1.4\text{ }^{\circ}\text{F}$) 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 LGR, LGF, or ULT shall be determined using the methodology set forth in 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.
- 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. Outer door gaskets shall be checked for adequacy of seal to the cabinet and adjusted, if required. Built-in 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.
- C) UUT Location: 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.
- 1) For pass-thru units, the UUT shall be placed in a way that allows both doors to be fully opened.
- D) Accessories: All accessories that come standard with the unit, as-shipped, and that consume energy 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 "ON" and set to the most energy consumptive setting during testing.
- E) Ambient Temperatures: The ambient temperatures shall be measured at the following locations
- 1) For Upright UUTs: Ambient temperature measurements shall be made at two locations, T_A and T_B , 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 \pm 50 mm (5.9 in. \pm 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 \pm 15 mm (36 in. \pm 2 in.) out from the door opening.
 - 2) For Chest-type UUTs: Ambient temperature measurements shall be made at two locations, T_A and T_B , above the UUT along a horizontal line at the centerline of the UUT in the door's longest dimension (either width or depth). T_A shall be placed 150 mm \pm 50 mm (5.9 in. \pm 2 in.) away from the door edge farthest along the door's centerline. T_B shall be placed at the geometric center of the door opening. Both points shall be located 915 mm \pm 15 mm (36 in. \pm 2 in.) above the door opening.
 - 3) For pass-thru UUTs, the ambient temperature shall be measured only on the side of the door opened during testing.
 - 4) If the placement of a TMD at either T_A or T_B interferes with the opening of the unit's door, the TMD shall be moved away from the UUT, perpendicular to the plane of the door opening, until it no longer interferes with the door opening.
- F) Temperature Measurement Devices:
- 1) Weighting: TMDs shall be placed inside a sealable plastic container (such as polyethylene) between 2 - 5 milliliters in volume and filled with any natural or artificial sponge material that is saturated with a heat transfer solution consisting of a 50/50 \pm 2% mixture (by volume) of propylene glycol and distilled water. The temperature shall be measured as closely as possible to the volumetric center of the container. TMDs shall be routed into the cabinet using an access port whenever possible.
 - 2) TMD Locations (Upright UUTs): TMDs shall be placed in 3 separate planes, one located 3 in. \pm 1 in. from the top of the UUT, one 3 in. \pm 1 in. from the bottom of the UUT, and one at the geometric center of the UUT. TMDs shall be placed in the geometric center and 3 in. \pm 1 in. diagonally from two opposite corners of each plane (3 sensors per plane).

- a. If the location of any TMD interferes with any hardware built into the UUT, move that plane of TMDs along the height of the UUT until the TMDs are at least 2 inches away from the hardware.
- b. If the UUT has inner doors, and a compartment created by the inner doors does not contain at least one TMD, place at least one TMD 3 in. \pm 1 in. above the geometric center of the bottom of that compartment.

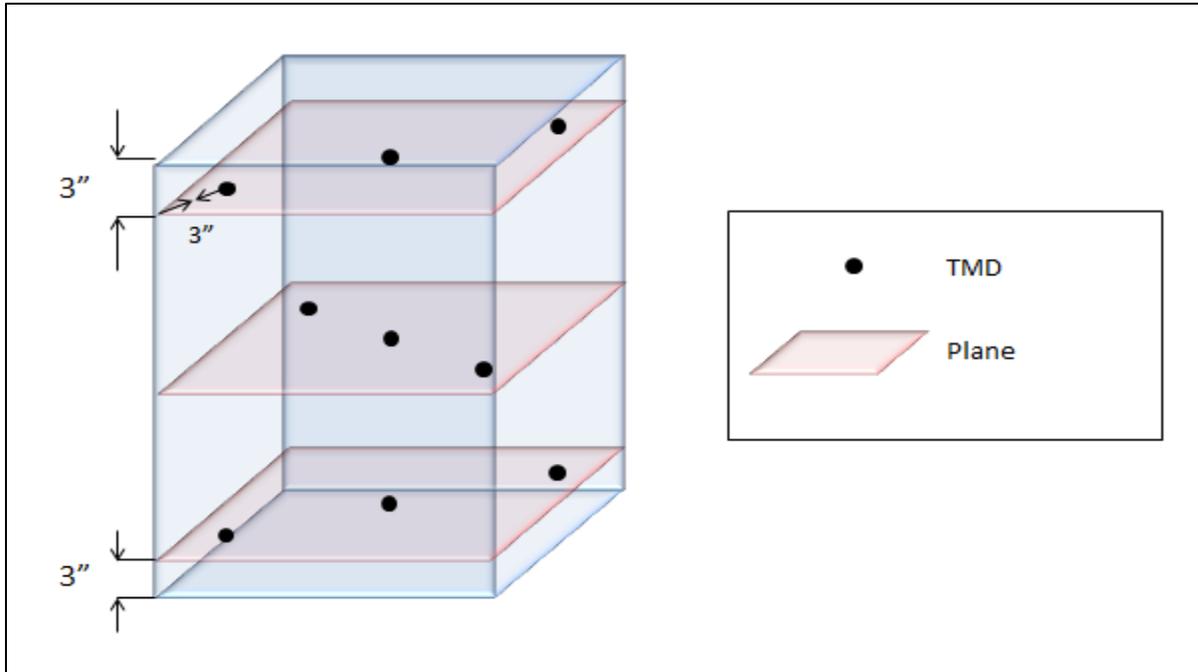


Figure 1. TMD Locations for Upright UUTs

- 3) **TMD Locations (Chest UUTs):** TMDs shall be located in planes 3 in. \pm 1 in. from the left end, 3 in. \pm 1 in. from the right end, and at the geometric center of the width of the unit. At each location, TMDs shall be placed in the geometric center of each plane and 5 in. \pm 1 in. diagonally from two opposite corners of each plane (3 sensors per plane).
 - a. If the location of any TMD interferes with any hardware built into the UUT, move that plane of TMDs along the width of the UUT until the TMDs are at least 2 inches away from the hardware.
 - b. If the UUT has multiple inner compartments, and one (or more) does not contain at least one TMD, place at least one TMD in the geometric center of each empty compartment.

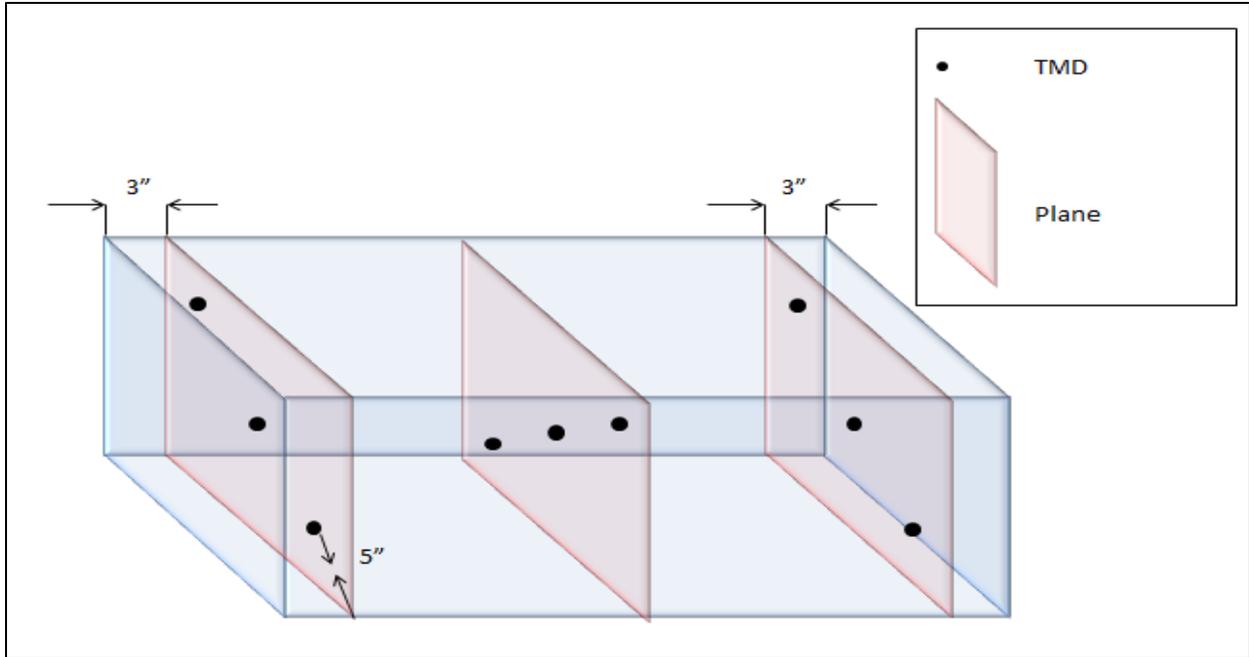


Figure 2. TMD Locations for Chest UUTs

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 across the face of the door opening 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.
 - b. Temperature recorded by each TMD in the cabinet.
 - c. Dry bulb temperature at points T_A and T_B .
 - d. Wet bulb temperature at points T_A and T_B .

- B) Cabinet Temperature Requirements: UUTs shall be calibrated so that the average of all Cabinet Temperature measurements, as defined in Section 3, over the course of the entire test period falls within the following ranges based on product type:

Table 1. Cabinet Temperature Requirements

Product Type	Cabinet Temperature and Acceptable Tolerance (°C)
LGR	4 ± 1
-20 °C LGF	-20 ± 1
-30 °C LGF	-30 ± 1
-40 °C LGF	-40 ± 1
ULT	-70 ± 1.5
	-80 ± 1.5

- 1) ULTs shall be tested at both -70 °C and -80 °C.
- 2) Non-ULT 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.

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 \pm 10 degrees (relative to the closed-door position). If the UUT has inner doors, inner doors shall be opened to an angle of 90 degrees \pm 10 degrees, and the main door shall be opened to an angle of 90 degrees \pm 10 degrees or to the smallest angle that will allow inner doors to be opened to an angle of 90 degrees \pm 10 degrees, whichever is largest.
- 2) For UUTs with sliding doors: Doors shall be opened as far as possible.
- 3) For UUTs with multiple outer doors: Only one outer door shall be opened at each door opening, and the largest shall be used for all door openings during a test.
 - a. For units with multiple doors of the same size, use the uppermost or rightmost door available depending on the unit's configuration.
 - b. For pass-thru UUTs, the door used for each opening shall be on the side of the UUT with TMDs for measuring the ambient temperature.

B) For Refrigerators: The UUT's door(s) shall be opened a total of 24 times during the test—three times per hour, every 20 minutes, for eight consecutive hours.

- 1) If the UUT has inner doors:
 - a. Open the outer door, as specified in Section 6.2.3), at a constant rate over a period of two seconds.
 - b. Open only the largest inner door at a constant rate over a period of two seconds. If more than one door is the same size, open the uppermost one of those doors (for upright freezers) or the rightmost one 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 two seconds.
 - e. Close outer door at a constant rate over a period of two seconds.
- 2) If the UUT does not have inner doors:
 - a. Open the outer door, as specified in Section 6.2.3), at a constant rate over a period of two seconds.
 - b. Leave door open for 15 seconds.
 - c. Close outer door at a constant rate over a period of two seconds.

C) For Freezers and ULTs: The UUT's door(s) shall be opened a total of six times during the test—once per hour, every 60 minutes, for a period of six consecutive hours.

- 2) If the UUT has inner doors:
 - a. Open the outer door, as specified in Section 6.2.3), at a constant rate over a period of two seconds.
 - b. Open only the largest inner door at a constant rate over a period of two seconds. If more than one door is the same size, open the uppermost one of those doors (for upright freezers) or the rightmost one 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 two seconds.
 - e. Close outer door at a constant rate over a period of two seconds.
- 3) If the UUT does not have inner doors:
- a. Open the outer door, as specified in Section 6.2.3), at a constant rate over a period of two seconds.
 - b. Leave door open for 15 seconds.
 - c. Close outer door at a constant rate over a period of two seconds.

6.3 Energy Consumption Test

- A) UUT Pull Down: The UUT shall be plugged in and turned on and the controls adjusted to ensure the UUT begins cooling to the appropriate Cabinet Temperature specified in Table 1. Prior to testing, the UUT shall be operated until the average of all Cabinet Temperatures measured during each of two periods separated by at least three hours lies within the Cabinet Temperature requirements, as specified in Table 1. The measurement periods are as follows:
- 1) For units that do not cycle, each measurement period shall be two hours.
 - 2) For units that do cycle, each measurement period shall comprise a number of complete, repetitive compressor cycles occurring through a period of no less than two hours.
- B) Test Periods: The test period shall be performed as described below based on the UUT's as-shipped defrost setting, after completion of the pull down period. 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) LGRs or LGFs with No Defrost, Manual Defrost, or Semi-Automatic Defrost: The test period shall be 24 hours with no defrost.
 - 2) LGRs or LGFs with Automatic Defrost: The test period shall be 24 hours starting at the beginning of a defrost period.
 - 3) ULTs: The test period shall be 24 hours.

7 REPORTING

- A) Cabinet Volume: The cabinet volume measured in Section 5.A shall be reported in cubic feet.
- B) Test Cabinet Temperature: The average Cabinet Temperature measured during the entire 24-hour test period shall be reported.
- C) Ambient Temperature: The average dry-bulb and wet-bulb temperatures measured at locations T_A and T_B shall be reported for the entire 24-hour test period.
- D) Power Factor: The average power factor over the course of a specified period, based on unit type, shall be reported.
- 1) For units that cycle, the average power factor measured during compressor "on" periods over the duration of the test.
 - 2) For units that do not cycle, the average power factor measured over the duration of the test.
- E) The following values shall be calculated and reported for two three hour periods during the test. The first period shall begin when the first door opening occurs. The second shall begin three hours after the last door opening occurs.
- 1) Test Uniformity: The cabinet Uniformity shall be calculated for the specified periods and reported by taking the average of the Uniformities calculated for each individual measurement.

- 2) Test Stability: The cabinet Stability shall be calculated for the specified periods and reported by taking the average of the Stabilities calculated for each TMD.
 - 3) The maximum and minimum measured temperatures and the Peak Variance measured across all TMDs.
- F) Accessories: A list of the accessories installed prior to testing.
- G) Energy Consumption:
- 1) For LGRs and LRFs:
 - a. The total energy consumption measured during the 24-hour test period shall be reported, in kWh/day.
 - b. The total energy consumption measured during the steady state portion of the test period, which starts one hour after the final door opening occurs, in kWh/day.
 - 2) For ULTs:
 - a. The total energy consumption measured during the 24-hour test period at both Cabinet Temperatures (as noted in Table 1) shall be reported, in kWh/day.
 - b. The total energy consumption measured during the steady state portion of the test period, which starts one hour after the final door opening occurs, at both Cabinet Temperatures, in kWh/day.
 - c. In addition, the energy consumption per day, in kWh/day, at Cabinet Temperature of -75 °C shall be calculated and reported as the weighted average of the test results at -70 °C and -80 °C, as follows:

Equation 1. ULT Energy Consumption Calculation

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

Where:

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

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

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

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

8 REFERENCES

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