



# ENERGY STAR® Program Requirements Product Specification for Residential Refrigerators, Refrigerator-Freezers, and Freezers

## Test Method to Validate Demand Response May-2013

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### 1 OVERVIEW

The following test method shall be used for determining product compliance with requirements for Demand Response (DR) functionality in the ENERGY STAR Refrigerator, Refrigerator-Freezer, and Freezer Connected Product Criteria.

### 2 APPLICABILITY

This test method is applicable to Refrigerators, Refrigerator-Freezers, and Freezers designed to meet the Connected Product Criteria in the ENERGY STAR Program Requirements Product Specification for Residential Refrigerators and Freezers – Eligibility Criteria Version 5.0.

### 3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Program Requirements Product Specification for Residential Refrigerators and Freezers – Eligibility Criteria Version 5.0 and in the DOE Test Procedure in 10 CFR Part 430, Subpart B, Appendix A and Appendix B (DOE Test Procedure).

- A) Utility Equivalent Communication Device: Device capable of communicating with the connected appliance and emulating signals sent from a utility. It will be controlled by the technician during the conduct of this test procedure, allowing the technician to deliver the Delay Appliance Load and Temporary Appliance Load Reduction signals.
- B) Appliance Communication Module: A built-in or external device that enables appliance bi-directional communication with the Utility Equivalent Communication Device.
- C) Connected Signal Simulation Hardware: Self-contained or Power Computer (PC) based hardware that will allow the technician to execute necessary communications and commands and receive necessary feedback from the Unit Under Test (UUT).
- D) Consumer Override: The capability for an end-user to cancel a product's response to a DR signal.
- E) Signals: Communications to a connected product that provide information or indicate that it should modify its operation. Signals include, but are not limited to, Delay Appliance Load (DAL), Temporary Appliance Load Reduction (TALR), and time-based pricing.
- F) Delay Appliance Load Capability: Capability of an appliance to reduce its average energy input over a specified time period. The delay load command provides the start time and duration of the delay load time period.
- G) Temporary Appliance Load Reduction Capability: Capability of an appliance to reduce its average energy input over a short specified time period. The temporary load reduction command provides the start time and duration of the temporary load reduction time period.
- H) Acronyms:
  - DR: Demand Response

- DAL: Delay Appliance Load
- TALR: Temporary Appliance Load Reduction
- Wh: Watt Hours
- kWh: Kilowatt Hours
- W: Watts
- UUT: Unit Under Test

## 4 TEST REQUIREMENTS

Unless otherwise specified, all test conditions and requirements shall be identical to Section 2 of the DOE Test Procedure.

## 5 PRE-TEST UUT CONFIGURATION

### 5.1 General Configuration

The UUT shall be set up as described in Section 3 of the DOE Test Procedure.

### 5.2 Communication Setup

The Appliance Communication Module and Utility Equivalent Communication Device shall be set up in accordance with manufacturer installation instructions. The communication device setup described below applies only to the Demand Response tests in Sections 7 and 8.

- A) Connect the Appliance Communication Module to the Utility Equivalent Communication Device via wired or wireless connection depending on the module's capability. A wireless connection is preferred if both are available.
- B) Ensure that the Appliance Communication Module is properly connected, is secured according to manufacturer instructions, and can both receive and send data to the Utility Equivalent Communication Device.

### 5.3 UUT Steady State Stabilization

- A) All compartment temperature controls shall be set at their median position, as described for the "first test" in Section 3.2.1 of the DOE Test Procedure.
- B) Prior to the start of testing, the UUT shall be stabilized according to Appendix A Section 2.9 or Appendix B Section 2.7 of the DOE Test Procedure.
- C) The ice maker shall be on with harvesting inoperative, as described in Section 2.2 of the DOE Test Procedure. The ice maker shall remain in this inoperative state throughout testing unless otherwise specified.
- D) If the UUT is equipped with an automatic ice maker, water line installation is required for the Ice Maker Deferral test in accordance with the printed instructions supplied with the cabinet or water line kit.

## 6 BASELINE ENERGY CONSUMPTION

### 6.1 DOE Baseline

- A) Measure the energy consumption,  $EP_1$ , in kWh, and length of time,  $T_1$ , in minutes, as described in Section 4.1 of the DOE Test Procedure. Conduct the test at the median temperature set point, as described in Section 3.2.1 of the DOE Test Procedure, with the anti-sweat heater switch, if present, in the “off” position.  $EP_1$  and  $T_1$  shall be represented in the DR calculations by  $EP_{BL}$  and  $T_{BL}$ .
- B) If the UUT has automatic defrost as specified in Section 4.2 of the DOE Test Procedure, and does not require the use of the two part test described in Sections 4.2.1 through 4.2.3:
  - 1) Select a stable test period consistent with that of the first part test of a Long-time Automatic Defrost unit as described in Section 4.2.1 of the DOE Test Procedure.
  - 2) Identify the energy consumed during the selected test period,  $EP_{AD}$ , in kWh, and the duration of the selected test period,  $T_{AD}$ , in minutes.  $EP_{AD}$  and  $T_{AD}$  shall be represented in the DR calculations by  $EP_{BL}$  and  $T_{BL}$ .

## 7 DELAY APPLIANCE LOAD (DAL) TEST

All connected features and network modes must be setup and enabled per Section 5.2, and the anti-sweat heater switch, if present, must be in the “off” position, during the Delay Appliance Load Test. As specified in the ENERGY STAR Program Requirements for Residential Refrigerators and Freezers Version 5.0, only one of the following tests in Section 7 are required for complying with Delay Appliance Load requirements.

### 7.1 Delay Appliance Load Test - Ice Maker Deferral

- A) Activate the ice maker harvest capabilities.
- B) Ensure that the ice maker is properly activated through the successful production of ice.
- C) Once ice making operations are activated, empty the ice bin, if necessary, and initiate a four-hour DAL signal.
- D) Ensure that all ice maker operations are deferred beyond the test period by confirming the ice bin is empty at the end of the four-hour test period.
- E) Verify no precooling cycle (as defined in Section 4.2.1.1 of the DOE Test Procedure) occurs and the defrost heater is off during the entire duration of the four-hour DAL test period.
- F) For the remainder of testing, return the ice maker to its inoperative state as described in Section 5.3.C and empty the ice bin if ice is present.

### 7.2 Delay Appliance Load Test - Percent Reduction

- A) Initiate a four-hour DAL signal within five minutes after the start of a compressor on cycle.
- B) Measure and record the energy consumption,  $EP_{DL}$ , in kWh, during the four-hour DAL test period.
- C) Verify no precooling cycle occurs and the defrost heater is off during the entire duration of the four-hour DAL test period.

## 8 TEMPORARY APPLIANCE LOAD REDUCTION (TALR) TEST

All connected features and network modes must be setup and enabled per Section 5.2, and the anti-sweat heater switch, if present, must be in the “off” position, during the Temporary Appliance Load Reduction Test.

### 8.1 Temporary Appliance Load Reduction Test

- A) Initiate a 10-minute TALR signal within five minutes after the start of a compressor on cycle.
- B) Measure and record the energy consumption,  $EP_{TALR}$ , in kWh, during the 10-minute TALR test period.
- C) Verify no precooling cycle occurs and the defrost heater is off during the entire duration of the 10-minute TALR test period.

## 9 CALCULATIONS

### 9.1 DR Baseline Average Power

Calculate the average DR baseline power,  $AP_{BL}$ .

#### Equation 1: DR Baseline Average Power

$$AP_{BL} = \frac{(EP_{BL} \times 1000)}{\left(\frac{T_{BL}}{60}\right)}$$

Where:

- $AP_{BL}$  is the average baseline power in W
- $EP_{BL}$  is the baseline energy consumption in kWh, as described in section 6.1
- 1000 is the conversion factor from kWh to Wh
- $T_{BL}$  is the baseline time period in minutes, as described in section 6.1
- 60 is the conversion factor from minutes to hours

### 9.2 Delay Load Period Average Power

If section 7.2 is performed, calculate the average delay load power,  $AP_{DL}$ .

#### Equation 2: Delay Load Average Power

$$AP_{DL} = \frac{(EP_{DL} \times 1000)}{4}$$

Where:

- $AP_{DL}$  is the average delay load power in W
- $EP_{DL}$  is the delay load energy consumption in kWh, as described in section 7.2
- 1000 is the conversion factor from kWh to Wh
- 4 is the delay load duration in hours

### 9.3 Percent Delay Load Average Power Reduction

If section 7.2 is performed, calculate the percent average delay load power reduction compared to the DR Baseline Test.

#### Equation 3: Percent Delay Load Average Power Reduction

$$\text{Percent Average Power Reduction} = \frac{(AP_{BL} - AP_{DL})}{AP_{BL}} \times 100\%$$

Where:

- $AP_{BL}$  is the average baseline power in W, as calculated in section 9.1
- $AP_{DL}$  is the average delay load power in W, as calculated in section 9.2

### 9.4 Temporary Appliance Load Reduction Average Power

Calculate the average TALR power,  $AP_{TALR}$ .

#### Equation 4: TALR Average Power

$$AP_{TALR} = \frac{(EP_{TALR} \times 1000)}{0.1667}$$

Where:

- $AP_{TALR}$  is the average TALR power in W
- $EP_{TALR}$  is the TALR energy consumption in kWh, as described in section 8.1
- 0.1667 is the time duration of the TALR period in hours

### 9.5 Percent TALR Average Power Consumed

Calculate the percent average TALR power consumed compared to the DOE Baseline Test.

#### Equation 5: Percent TALR Average Power Consumed

$$\text{Percent Average Power Consumed} = \frac{AP_{TALR}}{AP_{BL}} \times 100\%$$

Where:

- $AP_{BL}$  is the average baseline power in W, as calculated in section 9.1
- $AP_{TALR}$  is the average TALR power in W, as calculated in section 9.4

## 10 REFERENCES

- 10 CFR Part 430, Subpart B, Appendix A. Uniform Test Method for Measuring the Energy Consumption of Electric Refrigerators and Electric Refrigerator-Freezers.
- 10 CFR Part 430, Subpart B, Appendix B. Uniform Test Method for Measuring the Energy Consumption of Freezers.
- ENERGY STAR Program Requirements Product Specification for Residential Refrigerators and Freezers - Eligibility Criteria Version 5.0.