



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

## Draft 2 Test Method to Validate Demand Response Rev. Nov-2012

### 1 OVERVIEW

The following test method shall be used for determining product compliance with requirements for Demand Response (DR) functionality in the ENERGY STAR Eligibility Criteria for Connected Refrigerators, Freezers, and Refrigerator-Freezers (herein referred to as Connected R/F).

**Note:** The Draft 1 Test Method to Validate Demand Response (Draft 1) was published and presented to Stakeholders in February 2012. Draft 1 was developed based on a draft AHAM Test Procedure (AHAM SRF-0.5-2011) and investigative testing of a pre-market unit.

Following publication of the Draft 1 Test Method, DOE had the opportunity to test two additional pre-market units. Test results were combined with feedback received from stakeholders on Draft 1 and throughout the test method development process and were used as input to the Draft 2 Test Method.

Throughout this test method, DOE references the amended DOE Test Procedure in 10 CFR Part 430 Subpart B Appendix A and Appendix B (DOE Test Procedure) that goes into effect in 2014.

### 2 APPLICABILITY

This test method is applicable to refrigerators, refrigerator-freezers, and freezers intending to meet the Connected appliance requirements in the ENERGY STAR Version 5.0 Program Requirements.

### 3 DEFINITIONS

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

**Note:** The acronyms, definitions, and discussion below are included in the test method for initial discussion. Most definitions are reproduced from AHAM SRF-0.5-2011. All definitions and acronyms will eventually be moved to the specification document when ENERGY STAR Residential Refrigerators and Freezers Version 5.0 is published.

- 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 and will allow the technician to deliver the Delay Appliance Load and Temporary Appliance Load Reduction signals.
- B) Communication Module (Appliance): 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 operator 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.

- 33 E) Signals: Communications to a connected product that provide information or indicate that it should  
34 modify its operation. Signals include, but are not limited to, Delay Appliance Load (DAL), Temporary  
35 Appliance Load Reduction (TALR), and time-based pricing.
- 36 F) Delay Appliance Load Capability: Capability of an appliance to reduce its average energy input over a  
37 specified time period. The delay load command provides the start time and duration of the delay load  
38 time period.
- 39 G) Temporary Appliance Load Reduction Capability: Capability of an appliance to reduce its average  
40 energy input over a short specified time period. The temporary load reduction command provides the  
41 start time and duration of the temporary load reduction time period.
- 42 H) Acronyms:
- 43 • DR: Demand Response
  - 44 • DAL: Delay Appliance Load
  - 45 • TALR: Temporary Appliance Load Reduction
  - 46 • Hz: Hertz
  - 47 • Wh: Watt Hours
  - 48 • W: Watts
  - 49 • UUT: Unit Under Test
  - 50 • F: Fahrenheit
  - 51 • C: Celsius
  - 52 • R/E: Refrigerators, Freezers, and Refrigerator-Freezers

## 53 **4 TEST REQUIREMENTS**

54 Unless otherwise specified, all test conditions and requirements shall be identical to 10 CFR Part 430,  
55 Subpart B, Appendices A or B, Section 2.

56 **Note:** In response to comments received from stakeholders, the test requirements have been  
57 harmonized with the DOE test procedure. Unless otherwise specified, all test conditions directly reference  
58 the DOE test procedure.

## 59 **5 PRE-TEST UUT CONFIGURATION**

### 60 **5.1 General Configuration**

61 The UUT shall be set up as described in 10 CFR Part 430, Subpart B, Appendices A or B, Section 3.

### 62 **5.2 Communication Setup**

63 The communication device shall be set up in accordance with manufacturer installation instructions. The  
64 communication device setup described below applies only to the Demand Response tests in Sections 7  
65 and 8. The DOE Test Procedure shall provide guidance on the communication device setup for the DOE  
66 Baseline in Section 6.

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

### 72 5.3 UUT Steady State Stabilization

- 73 A) All compartment temperature controls shall be set at their median position, as described for the “first  
74 test” in 10 CFR 430, Subpart B, Appendix A or Appendix B, section 3.2.1.
- 75 B) Prior to the start of testing, the UUT shall be stabilized according to 10 CFR Part 430, Subpart B,  
76 Appendix A Section 2.9 or Appendix B Section 2.7.
- 77 C) The ice maker shall be on with harvesting inoperative, as described in Section 2.2 of the DOE Test  
78 Procedure. The ice maker shall remain in this inoperative state throughout testing unless otherwise  
79 specified.
- 80 D) If the UUT is equipped with an automatic ice maker, water line installation is required in accordance  
81 with the printed instructions supplied with the cabinet or water line for the Ice Maker Deferral test.

82 **Note:** There is currently no standard method for testing and measuring the energy consumption of  
83 automatic ice makers. Nevertheless, the ENERGY STAR Version 5.0 Draft 3 Specification includes ice  
84 making deferral as an alternative to a reduction in overall energy consumption. The test method will verify  
85 this deferral and requires that the ice maker be fully functioning and operative for a portion of testing (see  
86 Section 7.1).

## 87 6 BASELINE ENERGY CONSUMPTION

### 88 6.1 DOE Baseline

89 **Note:** The Draft 1 Test Method included a Baseline Test that differed slightly from the DOE Appendix A  
90 and B Test Procedures. After further review, DOE has proposed in the Draft 2 Test Method that the  
91 baseline for verifying DR capability shall be based on data collected from the DOE Test Procedure.  
92 Section 6.1 of the Draft 2 Test Method provides guidance on selecting the data from the DOE Test  
93 Procedure to represent the baseline average power. The data are selected from a test at the median  
94 compartment temperature setting, with no defrost occurrences, and with the anti-sweat heater switch in  
95 the “off” position. DOE believes that this baseline test period is most appropriate for comparing to the DR  
96 validation tests.

97  
98 DOE welcomes feedback on the proposed approach to use data from the DOE Test Procedure as a  
99 baseline for DR validation.

- 100 A) Measure the energy consumption,  $EP_1$ , in Wh, and length of time,  $T_1$ , in minutes, as described in  
101 Section 4.1 of the DOE Test Procedure. Conduct the test at the median temperature set point with the  
102 anti-sweat heater switch, if present, in the “off” position.  $EP_1$  and  $T_1$  shall be represented in the DR  
103 calculations by  $EP_{BL}$  and  $T_{BL}$ .

104 **Note:** DOE has included requirements for the anti-sweat heater switch configuration during the DOE  
105 Baseline test and ensuing DR Tests. In order to ensure comparable tests throughout, the anti-sweat  
106 heater switch, if available, shall be in the “off” position. The baseline average power will be determined  
107 from the portion of the DOE Test Procedure with the anti-sweat heater switch “off” and the DR test will be  
108 performed with the anti-seat heater switch in the same configuration. This approach reduces variability  
109 between tests for units that employ variable anti-sweat heaters which operate based on the ambient  
110 relative humidity.

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112 DOE welcomes feedback on the proposed anti-sweat heater switch configuration.

- 113 B) If the UUT has automatic defrost as specified in Section 4.2 of the DOE Test Procedure, and does not  
114 require the use of the two part test described in Sections 4.2.1 through 4.2.3:
- 115 1) Select a stable baseline period consistent with that of the first part test of a Long-time Automatic  
116 Defrost unit as described in Section 4.2.1 of the DOE Test Procedure.

- 117 2) Identify the energy consumed,  $EP_{AD}$ , in Wh, and length of time,  $T_{AD}$ , in minutes, from within the  
118 selected test period.  $EP_{AD}$  and  $T_{AD}$  shall be represented in the DR calculations by  $EP_{BL}$  and  $T_{BL}$ .

## 119 7 DELAY APPLIANCE LOAD (DAL) TEST

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

### 125 7.1 Delay Appliance Load Test - Ice Maker Deferral

- 126 A) Activate the ice maker harvest capabilities.  
127 B) Ensure that the ice maker is properly activated through the successful production of ice.  
128 C) Once ice making operations are activated, empty the ice bin, if necessary, and initiate a four-hour  
129 DAL signal.  
130 D) Ensure that all ice maker operations are deferred beyond the test period by confirming the ice bin is  
131 empty at the end of the four-hour test period.  
132 E) Verify no defrost cycle occurs within four hours of the initiation of the DAL signal.  
133 F) For the remainder of testing, return the ice maker to its inoperative state as described in Section  
134 5.3.C and empty the ice bin if ice is present.

135 **Note:** The ENERGY STAR Program Requirements for Residential Refrigerators and Freezers Version  
136 5.0 Draft 3 proposes the following requirements for DAL:

137 *Upon receipt of signal and in accordance with the consumer settings, except as permitted below, the*  
138 *product shall:*

- 139 A) *Shift its defrost cycle(s) beyond the delay period, and*  
140 B) *Either shift ice maker cycles beyond the delay period or reduce its average power draw during the*  
141 *delay period by at least 13% relative to the average power drawn during an average load over a 24-*  
142 *hour period as defined by the Baseline Test in the Test Method to Validate Demand Response.*

143 The DOE Test Procedure does not include a method for estimating ice maker energy consumption. DOE  
144 is conducting a rulemaking to address ice maker energy. However, because Section 4H of the Version  
145 5.0 Draft 3 Eligibility Criteria includes ice maker deferral requirements, DOE has included a method for  
146 verifying the delay of ice making operations during the DAL test period.

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148 DOE requests feedback on the ice making deferral test and average power percent reduction tests.

### 149 7.2 Delay Appliance Load Test - Percent Reduction

- 150 A) Initiate a four-hour DAL signal within five minutes after the start of a compressor on cycle.  
151 B) Measure and record the energy consumption,  $EP_{DL}$ , during the four-hour DAL test period.  
152 C) Verify no defrost cycle occurs within four hours of the initiation of the DAL signal.

153 **8 TEMPORARY APPLIANCE LOAD REDUCTION (TALR) TEST**

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

157 **Note:** The ENERGY STAR Program Requirements for Residential Refrigerators and Freezers Version  
158 5.0 Draft 3 proposes the following requirements for TALR:  
159 *Upon receipt of signal and in accordance with consumer settings, except as permitted below, the product*  
160 *shall restrict its average power draw during the load reduction period to no more than 50% of the average*  
161 *power draw during an average load over a 24-hour period as defined by the DR baseline Test in the Test*  
162 *Method to Validate Demand Response.*  
163 The requirements state that no additional defrost cycles shall occur during the time period. In Draft 1 DOE  
164 proposed a straw-man door-opening method for initiating a defrost operation in order to verify defrost  
165 deferral during the DR period. Based on stakeholder feedback and additional testing, DOE has  
166 determined that defrost prediction and/or initiation are not feasible at this time and is proposing in the  
167 Draft 2 Test Method that defrost deferral will not be validated through testing; however, Draft 2 requires  
168 the test lab to document the occurrence of any defrost cycle during a TALR signal.

169 **8.1 Temporary Appliance Load Reduction Test**

- 170 A) Initiate a 10-minute TALR signal within five minutes after the start of a compressor on cycle.  
171 B) Measure and record the energy consumption, EP<sub>TALR</sub>, during the 10-minute TALR test period.  
172 C) Verify no defrost cycle occurs during the TALR signal test period.

173 **9 CALCULATIONS**

174 **9.1 DR Baseline Average Power**

175 Calculate the average DR baseline power, AP<sub>BL</sub>.

176 **Equation 1: DR Baseline Average Power**

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

177 *Where:*

- 178 • AP<sub>BL</sub> is the average baseline power in W
- 179 • EP<sub>BL</sub> is the baseline energy consumption in kWh, as  
180 described in section 6.1
- 181 • 1000 is the conversion factor from kWh to Wh
- 182 • T<sub>BL</sub> is the baseline time period in minutes, as described in  
183 section 6.1
- 184 • 60 is the conversion factor from minutes to hours

185 **9.2 Delay Load Period Average Power**

186 Calculate the average delay load power, AP<sub>DL</sub>.

187 **Equation 2: Delay Load Average Power**

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

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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

### 194 9.3 Percent Delay Load Average Power Reduction

195 Calculate the percent average delay load power reduction compared to the DR Baseline Test.

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

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

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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

### 203 9.4 Temporary Appliance Load Reduction Average Power

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

#### 205 Equation 4: TALR Average Power

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

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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

### 211 9.5 Percent TALR Average Power Consumed

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

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

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

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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

## 219 10 REFERENCES

- 220 A) 10 CFR Part 430, Subpart B, Appendix A. Uniform Test Method for Measuring the Energy  
221 Consumption of Electric Refrigerators and Electric Refrigerator-Freezers.

- 222 B) 10 CFR Part 430, Subpart B, Appendix B. Uniform Test Method for Measuring the Energy  
223 Consumption of Freezers.
- 224 C) AHAM SRF-0.5-2011. AHAM Smart Refrigerator, Refrigerator-Freezer, and Freezer Test Procedure.  
225 Draft shared with DOE September 2011.
- 226 D) ENERGY STAR Program Requirements for Residential Refrigerators and Freezers - Eligibility Criteria  
227 Version 5.0 Draft 3 published September 2012.