



ENERGY STAR® Program Requirements Product Specification for Room Air Conditioners

Test Method to Validate Demand Response June 2017

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 Room Air Conditioners.

2 APPLICABILITY

This test method is applicable to Room Air Conditioners designed to meet the connected product criteria in the ENERGY STAR Version 4.0 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 Room Air Conditioners Version 4.0 and in the U.S. Department of Energy (DOE) Test Procedure in Title 10 of the Code of Federal Regulations (CFR) Part 430, Appendix F to Subpart B (DOE Test Procedure).

- A) Utility Equivalent Communication Device: Self-contained or Personal Computer (PC)-based device or devices capable of communicating with the connected appliance and simulating signals sent from a utility. The utility equivalent communication device or devices will be controlled by the technician during the conduct of this test procedure, allowing the technician to execute and deliver the Delay Appliance Load and Temporary Appliance Load Reduction signals and receive necessary feedback from the Unit Under Test (UUT).
- B) Appliance Communication Module: A built-in or external device that enables appliance bi-directional communication with the Utility Equivalent Communication Device.
- C) Consumer Override: The capability for an end-user to cancel a product's response to a DR signal.
- D) 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) and Temporary Appliance Load Reduction (TALR).
- E) Delay Appliance Load Capability: The capability of the product to respond to a signal in accordance with consumer settings; by increasing the set temperature by at least 4°F for at least 4 hours.
- F) Temporary Appliance Load Reduction Capability: The capability of the product to respond to a signal in accordance with consumer settings; by disabling compressor operation for at least 10 minutes.
- G) Unit Demand Response Reset: The act of resetting the UUT such that it may respond to further DAL signals within a 24-hour rolling period, or further TALR signals within a 1-hour rolling period. If the unit cannot be reset, the unit reset steps shall be replaced by allowing the unit to run for the necessary time for new signals to be accepted according to the ENERGY STAR Certification Criteria.
- H) Cooling Mode: The user-selectable mode that requires the UUT to provide cooling through use of the refrigeration cycle. In cases where more than one cooling mode is offered, the term "cooling mode" shall refer to the mode that offers the highest cooling capacity.

I) Air Circulation Mode: The user-selectable mode that requires the UUT to circulate air through operation of the fan, without providing cooling through use of the refrigeration cycle.

J) 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

The indoor and outdoor sides of the UUT do not need be isolated from each other. Consequently, the UUT may be tested inside a single room or chamber. However, a setup with two rooms (such as in the DOE Test Procedure) is also acceptable. The ambient temperature must be controlled in the TALR test as described in subsection 4.2. In case two rooms are used, the temperature in both rooms must be kept within the limits described herein.

4.1 Delay Appliance Load (DAL) Test

No specific test conditions are required for the Delay Appliance Load test.

4.2 Temporary Appliance Load Reduction (TALR) Test

For the Temporary Appliance Load Reduction test (Section 8), the ambient temperature must be maintained at $95\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$ at all times.

5 PRE-TEST UUT CONFIGURATION

5.1 General Configuration

The UUT shall be installed according to the instructions provided by the manufacturer. Ensure that the tilt of the UUT matches the conditions required by the manufacturer.

5.2 Communication Setup

The Appliance Communication Module and Utility Equivalent Communication Device shall be set up in accordance with manufacturer instructions. The communication devices must be set up as follows:

- A) Establish the connection between the Appliance Communication Module and 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 and can both receive and send data to the Utility Equivalent Communication Device, in accordance with manufacturer instructions.

6 MEASUREMENTS

6.1 Set Temperature

The set temperature of the UUT shall be determined during testing using the consumer interface in accordance with manufacturer instructions. The consumer interface may be, for example, the display on the UUT itself or a remote control, or on a manufacturer-approved mobile or computer application. The UUT set temperature shall not be modified during testing unless explicitly required in this test method. The set temperature determination must not override the UUT response to a demand response signal.

6.2 Ambient Temperature

Ambient temperature shall be measured using a temperature sensor with an accuracy of 1 °F. The temperature sensor shall be placed centered in front of the evaporator inlet area and no more than 2 inches away from it. Each temperature reading shall be the average of the temperature measurements taken over a 10-second period.

6.3 Elapsed Time

Elapsed time periods shall be measured with any time keeping device of resolution greater or equal to 1 second.

6.4 Electrical Power Input

Power measurement instruments shall have an accuracy of 1% of the measured quantity. Each power reading shall be the average of the power measurements taken over a 10-second period. Where the measurements must be taken within a certain time interval, the 10-second averaging period must coincide, at least in part, with the specified interval.

7 DELAY APPLIANCE LOAD (DAL) TEST

All connected features and network modes must be setup and enabled per Section 5.2 during the Delay Appliance Load Test. All DAL tests must be conducted with the UUT set to cooling mode.

7.1 Standard Response

- 7.1.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or below 70 °F.
- 7.1.2 Record the UUT set temperature, T_1 .
- 7.1.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer instructions.
- 7.1.4 Record the UUT set temperature nine times within the 4-hour DAL period. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the DAL signal. The next seven readings shall be taken at an elapsed time of 30, 60, 90, 120, 150, 180 and 210 minutes following verification that the UUT received the DAL signal, each with a tolerance of ± 1 minute. The final, ninth, reading shall be taken at an elapsed time between 239 and 240 minutes following verification that the UUT received the DAL signal. Determine the minimum of the nine readings, $T_{S, min}$. Determine the maximum of the nine readings, $T_{S, max}$.
- 7.1.5 After a period of 24 hours from the start of the DAL signal, initiate step 7.2.1.

7.2 High Temperature Response

- 7.2.1 Set the UUT set temperature to the nearest user-selectable temperature increment below 85 °F.

- 7.2.2 Record the UUT set temperature, T_2 .
- 7.2.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer instructions.
- 7.2.4 Record the UUT set temperature two times within the 10-minute period following the DAL signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the DAL signal. The second reading shall be taken at an elapsed time between 9 and 10 minutes following verification that the UUT received the DAL signal. Determine the maximum of the two readings, T_H .
- 7.2.5 Conduct a Unit Demand Response Reset of the UUT between minutes 10 and 11.

7.3 Upper Temperature Limit

- 7.3.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or above 85 °F.
- 7.3.2 Record the UUT set temperature, T_3 .
- 7.3.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer instructions.
- 7.3.4 Record the UUT set temperature two times within the 10-minute period following the DAL signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the DAL signal. The second reading shall be taken at an elapsed time between 9 and 10 minutes following verification that the UUT received the DAL signal. Determine the maximum of the two readings, T_U .
- 7.3.5 Conduct a Unit Demand Response Reset of the UUT between minutes 10 and 11.

7.4 Active Override

- 7.4.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or below 70 °F.
- 7.4.2 Record the UUT set temperature, T_4 .
- 7.4.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer instructions.
- 7.4.4 Record the UUT set temperature two times within the 5-minute period following the DAL signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the DAL signal. The second reading shall be taken at an elapsed time between 4 and 5 minutes following verification that the UUT received the DAL signal. Determine the minimum of the two readings, T_V .
- 7.4.5 Override the DAL signal according to manufacturer instructions, at an elapsed time between 5 and 10 minutes following verification that the UUT received the DAL signal.
- 7.4.6 Record the UUT set temperature two times within the 10-minute period following the activation of the override. The first reading shall be taken at an elapsed time between 15 and 45 seconds following the activation of the override. The second reading shall be taken at an elapsed time between 9 and 10 minutes following activation of the override. Determine the maximum of the two readings, T_A .
- 7.4.7 Conduct a Unit Demand Response Reset of the UUT.

7.5 Compliance Verification

The UUT will have passed the test if all of the statements in Section 7.5.1 through Section 7.5.5 are true:

- 7.5.1 $85\text{ °F} \geq T_{S,max} \geq T_{S,min} \geq T_1 + 4\text{ °F}$

7.5.2 $85\text{ }^{\circ}\text{F} = T_H > T_2 \geq 81\text{ }^{\circ}\text{F}$; otherwise $85\text{ }^{\circ}\text{F} > T_H \geq T_2 + 4\text{ }^{\circ}\text{F}$

7.5.3 $T_U = T_3$

7.5.4 $T_V \geq T_4 + 4\text{ }^{\circ}\text{F}$

7.5.5 $T_A = T_4$

8 TEMPORARY APPLIANCE LOAD REDUCTION (TALR) TEST

All connected features and network modes must be setup and enabled per Section 5.2 during the Temporary Appliance Load Reduction Test. All TALR tests must be conducted in cooling mode, with the exception of Section 8.1.

8.1 Air Circulation Mode Power Measurement

8.1.1 Set the UUT to air circulation mode and, for models that have a user-selectable fan speed, adjust the fan speed to the highest setting.

8.1.2 Run the UUT for 15 minutes.

8.1.3 Record the electrical power input to the UUT eleven times in the 10-minute period following the 15-minute operating period. The first reading shall be taken at an elapsed time between 15 and 45 seconds after the start of the 10-minute period. The next nine readings shall be taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes after the start of the 10-minute period, with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes and 45 seconds after the start of the 10-minute period, with a tolerance of ± 5 seconds.

8.1.4 Average all readings to obtain P_{circ} .

8.2 Standard Response

8.2.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or below $70\text{ }^{\circ}\text{F}$.

8.2.2 Run the UUT for 15 minutes and record the electrical power input to the UUT eleven times within the 15-minute period. The first reading shall be taken at an elapsed time between 5 minutes 15 seconds and 5 minutes 45 seconds from the start of the 15-minute period. The next nine readings shall be taken at an elapsed time of 6, 7, 8, 9, 10, 11, 12, 13 and 14 minutes from the start of the 15-minute period, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 14 minutes 45 seconds from the start of the 15-minute period, with a tolerance of ± 5 seconds. Determine the minimum of the eleven electrical power input measurements, $P_{S,on,1}$.

8.2.3 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to manufacturer instructions.

8.2.4 Record the electrical power input to the UUT eleven times within the 10-minute period following the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the TALR signal. The next nine readings shall be taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT received the TALR signal, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR signal, with a tolerance of ± 5 seconds. Determine the maximum of the eleven electrical power input measurements, $P_{S,off,1}$.

8.2.5 Continue to run the UUT for 70 minutes after the last reading.

- 8.2.6 Record the electrical power input to the UUT eleven times within a 10-minute period following the 70-minute operating period. The first reading shall be taken at an elapsed time between 15 and 45 seconds from the start of the 10-minute period. The next nine readings shall be taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes from the start of the 10-minute period, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45 seconds from the start of the 10-minute period, with a tolerance of ± 5 seconds. Determine the minimum of the eleven electrical power input measurements, $P_{S,on,2}$.
- 8.2.7 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to manufacturer instructions.
- 8.2.8 Record the electrical power input to the UUT eleven times within the 10-minute period following the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the TALR signal. The next nine readings shall be taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT received the TALR signal, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR signal, with a tolerance of ± 5 seconds. Determine the maximum of the eleven electrical power input measurements, $P_{S,off,2}$.
- 8.2.9 Continue to run the UUT for 70 minutes after the last reading.
- 8.2.10 Record the electrical power input to the UUT eleven times within a 10-minute period following the 70-minute operating period. The first reading shall be taken at an elapsed time between 15 and 45 seconds from the start of the 10-minute period. The next nine readings shall be taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes from the start of the 10-minute period, with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45 seconds from the start of the 10-minute period, with a tolerance of ± 5 seconds. Determine the minimum of the eleven electrical power input measurements, $P_{S,on,3}$.
- 8.2.11 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to manufacturer instructions.
- 8.2.12 Record the electrical power input to the UUT eleven times within the 10-minute period following the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the TALR signal. The next readings shall be taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT received the TALR signal, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR signal, with a tolerance of ± 5 seconds. Determine the maximum of the eleven electrical power input measurements, $P_{S,off,3}$.

8.3 24-hour Rolling Period Response

- 8.3.1 Continue to run the UUT until 24 hours have elapsed from the initiation of the TALR signal in section 8.2.3.
- 8.3.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to manufacturer instructions.
- 8.3.3 Record the electrical power input to the UUT eleven times within the 10-minute period following the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the TALR signal. The next nine readings shall be taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT received the TALR signal, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR signal, with a tolerance of ± 5 seconds. Determine the maximum of the eleven electrical power input measurements, P_R .
- 8.3.4 Conduct a Unit Demand Response Reset of the UUT.

8.4 Upper Temperature Limit Response

- 8.4.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or above 85 °F.
- 8.4.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to manufacturer instructions.
- 8.4.3 Record the electrical power input to the UUT eleven times within the 10-minute period following the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the TALR signal. The next nine readings shall be taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT received the TALR signal, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR signal, with a tolerance of ± 5 seconds. Determine the maximum of the eleven electrical power input measurements, P_U .
- 8.4.4 Conduct a Unit Demand Response Reset of the UUT.

8.5 Active Override

- 8.5.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or below 70 °F.
- 8.5.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to manufacturer instructions.
- 8.5.3 Record the electrical power input to the UUT six times within the 5-minute period following the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds following verification that the UUT received the TALR signal. The next four readings shall be taken at an elapsed time of 1, 2, 3 and 4 minutes following verification that the UUT received the TALR signal, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 4 minutes 45 seconds following verification that the UUT received the TALR signal, with a tolerance of ± 5 seconds. Determine the maximum of the six electrical power input measurements, $P_{A,off}$.
- 8.5.4 Override the TALR signal according to manufacturer instructions, 5 minutes (± 5 seconds) following verification that the UUT received the initial TALR signal.
- 8.5.5 Record the electrical power input to the UUT eleven times within the 13-minute period following the override signal. The first reading shall be taken at an elapsed time between 3 minutes 15 seconds and 3 minutes 45 seconds following the activation of the override. The next nine readings shall be taken at an elapsed time of 4, 5, 6, 7, 8, 9, 10, 11 and 12 minutes following activation of the override, each with a tolerance of ± 5 seconds. The last reading shall be taken at an elapsed time of 12 minutes 45 seconds following activation of the override, with a tolerance of ± 5 seconds. Determine the maximum of the eleven electrical power input measurements, $P_{A,on}$.
- 8.5.6 Conduct a Unit Demand Response Reset of the UUT.

8.6 Compliance Verification

The UUT will have passed the test if all of the statements in Section 8.6.1 through Section 8.6.5 are true:

- 8.6.1 $P_{S,on,(i)} \geq 2 \times P_{circ}$ and $P_{S,off,(i)} < 2 \times P_{circ}$, where i refers to each of the three test cycles in section 8.2
- 8.6.2 $P_R < 2 \times P_{circ}$
- 8.6.3 $P_U \geq 2 \times P_{circ}$
- 8.6.4 $P_{A,off} < 2 \times P_{circ}$
- 8.6.5 $P_{A,on} \geq 2 \times P_{circ}$

9 REFERENCES

- A) 10 CFR Part 430, Subpart B, Appendix F. Uniform Test Method for Measuring the Energy Consumption of Room Air Conditioners.
- B) ENERGY STAR Program Requirements for Room Air Conditioners - Eligibility Criteria - Version 4.0.