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.

Note: This document contains the proposed ENERGY STAR test method for evaluating the demand response capabilities of room air conditioners. The proposed test method provides a means for validating the demand response requirements contained in the connected product criteria of the ENERGY STAR Product Specification for Room Air Conditioners, Eligibility Criteria, Version 4.0.

The U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) invite stakeholders to comment on the proposed test method for evaluating room air conditioner demand response capabilities, outlined below. Specific topics for which DOE and EPA request comment are addressed in note boxes similar to this one.

Please send comments via email to appliances@energystar.gov no later than March, 9 2017.

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 °F ± 5 °F at all times.

**Note:** The UUT’s specific component operation (i.e., compressor or fan operation) are not expected to affect the results of the DAL test and therefore, to minimize test burden, DOE and EPA did not specify test conditions for the DAL test.

The ambient conditions for the TALR test were selected to ensure continuous compressor operation at a set temperature of 85 °F, or the next increment above 85 °F. DOE and EPA specified a large tolerance on the TALR ambient temperature to minimize test burden and avoid the need for expensive chamber conditioning equipment.

DOE and EPA invite stakeholder comments on the lack of specific test conditions for the DAL test and the test conditions specified for the TALR test.
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 according to manufacturer instructions, and can both receive and send data to the Utility Equivalent Communication Device.

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 UUT set temperature may be visible, for example, through a display on the UUT itself or on a mobile or computer application. The UUT set temperature shall not be modified during testing unless explicitly required in this test method.

Note: The process to access the set temperature may vary among manufacturers depending upon the specific consumer interface and programming and, therefore, only general instructions to retrieve the UUT set temperature are specified. Further, DOE and EPA are aware of models for which there is a risk that incorrect use of the consumer interface could accidentally override an ongoing signal response, and therefore require that the set temperature shall not be modified during testing and that the UUT set temperature shall be determined in accordance with manufacturer instructions.

DOE and EPA invite stakeholder comments on the proposed procedure to access the UUT set temperature and potential means to avoid the accidental override of a signal response during testing.

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, $T_{S,\text{min}}$. Determine the maximum of the nine readings, $T_{S,\text{max}}$.

7.1.5 After a period of 24 hours from the start of the DAL signal, initiate step 7.2.1.

Note: It may take a brief period of time for a UUT to adjust the set temperature in response to a DAL demand response signal, once it is received. Therefore, DOE and EPA have included a short 15 to 45 second allowance after verifying that the UUT complies with the received signal and before the set point is adjusted.

DOE and EPA invite stakeholder comments on this delayed response time allowance and the specific measurement interval provided to ensure that the unit has time to respond to the received DAL signal.

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, $T_{H\text{,max}}$.

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, $T_A$.

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.

**Note:** Consumer override is a key component of the Demand Response Connected Product Criteria in the current ENERGY STAR Program Requirements for Room Air Conditioners, Eligibility Criteria Version 4.0. Therefore, DOE and EPA have developed the above series of test in section 7.4 to confirm the override functionality is included and functional.

DOE and EPA invite stakeholder comments on this active override test.

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 $85 \, ^\circ F \geq T_{S,\text{max}} \geq T_{S,\text{min}} \geq T_1 + 4 \, ^\circ F$

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

7.5.3 $T_U = T_3$

7.5.4 $T_V \geq T_4 + 4 \, ^\circ F$

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 $P_{\text{circ}}$.

8.2 Standard Response

8.2.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or below 70 °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, $P_{S,\text{on},1}$.

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, $P_{S,\text{off},1}$.

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, $P_{S,\text{on},2}$.

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, $P_{S,off.3}$.

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 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, $P_{S,off.3}$.

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, $P_{A,off}$.

8.5.6 Conduct a Unit Demand Response Reset of the UUT.

Note: Consumer override is a key component of the Demand Response Connected Product Criteria in the current ENERGY STAR Program Requirements for Room Air Conditioners, Eligibility Criteria Version 4.0. Therefore, DOE and EPA have developed the above series of test in section 8.5 to confirm the override functionality is included and functional.

DOE and EPA invite stakeholder comments on this active override test.

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 \( P_{S_{\text{on}},(i)} \geq 2 \times P_{\text{circ}} \) and \( P_{S_{\text{off}},(i)} < 2 \times P_{\text{circ}} \), where \( i \) refers to each of the three test cycles in section 8.2.

8.6.2 \( P_{R} < 2 \times P_{\text{circ}} \)

8.6.3 \( P_{U} \geq 2 \times P_{\text{circ}} \)

8.6.4 \( P_{A_{\text{off}}} < 2 \times P_{\text{circ}} \)

8.6.5 \( P_{A_{\text{on}}} \geq 2 \times P_{\text{circ}} \)

**Note:** DOE and EPA determined that the cooling mode input power is typically at least two times the input power for other modes in which the compressor is not operating. For that reason, compliance verification is based on the measured power being greater than or equal to two times the input power in air circulation mode, as determined in section 8.6.1, to establish the presence of compressor operation.

DOE and EPA invite stakeholder comments on the method to determine the compressor operating status.

### 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.