



ENERGY STAR® Program Requirements Product Specification for Room Air Conditioners

Draft Final Test Method to Validate Demand Response May 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.

Note: This document contains the final draft ENERGY STAR test method for evaluating the demand response capabilities of room air conditioners. The final draft 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) thank stakeholders for their comments on the proposed test method for evaluating room air conditioner demand response capabilities. Specific topics for which DOE and EPA requested and received comment are addressed in note boxes similar to this one, and in the accompanying comment-response matrix.

Any final comments may be submitted via email to appliances@energystar.gov no later than May 26, 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).

- 35 E) Delay Appliance Load Capability: The capability of the product to respond to a signal in accordance
36 with consumer settings; by increasing the set temperature by at least 4°F for at least 4 hours.
- 37 F) Temporary Appliance Load Reduction Capability: The capability of the product to respond to a signal
38 in accordance with consumer settings; by disabling compressor operation for at least 10 minutes.
- 39 G) Unit Demand Response Reset: The act of resetting the UUT such that it may respond to further DAL
40 signals within a 24-hour rolling period, or further TALR signals within a 1-hour rolling period. If the unit
41 cannot be reset, the unit reset steps shall be replaced by allowing the unit to run for the necessary
42 time for new signals to be accepted according to the ENERGY STAR Certification Criteria.
- 43 H) Cooling Mode: The user-selectable mode that requires the UUT to provide cooling through use of the
44 refrigeration cycle. In cases where more than one cooling mode is offered, the term “cooling mode”
45 shall refer to the mode that offers the highest cooling capacity.
- 46 I) Air Circulation Mode: The user-selectable mode that requires the UUT to circulate air through
47 operation of the fan, without providing cooling through use of the refrigeration cycle.
- 48 J) Acronyms:
- 49 • DR: Demand Response
 - 50 • DAL: Delay Appliance Load
 - 51 • TALR: Temporary Appliance Load Reduction
 - 52 • Wh: Watt Hours
 - 53 • kWh: Kilowatt Hours
 - 54 • W: Watts
 - 55 • UUT: Unit Under Test

56 **4 TEST REQUIREMENTS**

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

62 **4.1 Delay Appliance Load (DAL) Test**

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

64 **4.2 Temporary Appliance Load Reduction (TALR) Test**

65 For the Temporary Appliance Load Reduction test (Section 8), the ambient temperature must be
66 maintained at 95 °F ± 5 °F at all times.

67 **5 PRE-TEST UUT CONFIGURATION**

68 **5.1 General Configuration**

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

71 **5.2 Communication Setup**

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

- 74 A) Establish the connection between the Appliance Communication Module and the Utility Equivalent
75 Communication Device via wired or wireless connection depending on the module's capability. A
76 wireless connection is preferred if both are available.
- 77 B) Ensure that the Appliance Communication Module is properly connected and can both receive and
78 send data to the Utility Equivalent Communication Device, in accordance with manufacturer
79 instructions.

80 **6 MEASUREMENTS**

81 **6.1 Set Temperature**

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

87 **Note:** DOE and EPA clarify that the UUT set temperature may be determined using any manufacturer-
88 provided consumer interface, including the display on the UUT or remote control, or a mobile or computer
89 application.

90

91 **Note:** DOE and EPA believe there is a potential risk that incorrect use of the consumer interface in
92 determining the set temperature could accidentally adjust the set temperature or override an ongoing
93 signal response, and therefore include provisions that the set temperature shall not be modified during
94 testing and the demand response signal must not be overridden in determining the set temperature.

95 **6.2 Ambient Temperature**

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

100 **6.3 Elapsed Time**

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

103 **6.4 Electrical Power Input**

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

108 **7 DELAY APPLIANCE LOAD (DAL) TEST**

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

111 **7.1 Standard Response**

- 112 7.1.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
113 below 70 °F.
- 114 7.1.2 Record the UUT set temperature, T_1 .
- 115 7.1.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer
116 instructions.
- 117 7.1.4 Record the UUT set temperature nine times within the 4-hour DAL period. The first reading shall
118 be taken at an elapsed time between 15 and 45 seconds following verification that the UUT
119 received the DAL signal. The next seven readings shall be taken at an elapsed time of 30, 60, 90,
120 120, 150, 180 and 210 minutes following verification that the UUT received the DAL signal, each
121 with a tolerance of +/- 1 minute. The final, ninth, reading shall be taken at an elapsed time
122 between 239 and 240 minutes following verification that the UUT received the DAL signal.
123 Determine the minimum of the nine readings, $T_{S, min}$. Determine the maximum of the nine
124 readings, $T_{S, max}$.
- 125 7.1.5 After a period of 24 hours from the start of the DAL signal, initiate step 7.2.1.

126 **7.2 High Temperature Response**

- 127 7.2.1 Set the UUT set temperature to the nearest user-selectable temperature increment below 85 °F.
- 128 7.2.2 Record the UUT set temperature, T_2 .
- 129 7.2.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer
130 instructions.
- 131 7.2.4 Record the UUT set temperature two times within the 10-minute period following the DAL signal.
132 The first reading shall be taken at an elapsed time between 15 and 45 seconds following
133 verification that the UUT received the DAL signal. The second reading shall be taken at an
134 elapsed time between 9 and 10 minutes following verification that the UUT received the DAL
135 signal. Determine the maximum of the two readings, T_H .
- 136 7.2.5 Conduct a Unit Demand Response Reset of the UUT between minutes 10 and 11.

137 **7.3 Upper Temperature Limit**

- 138 7.3.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
139 above 85 °F.
- 140 7.3.2 Record the UUT set temperature, T_3 .
- 141 7.3.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer
142 instructions.
- 143 7.3.4 Record the UUT set temperature two times within the 10-minute period following the DAL signal.
144 The first reading shall be taken at an elapsed time between 15 and 45 seconds following
145 verification that the UUT received the DAL signal. The second reading shall be taken at an
146 elapsed time between 9 and 10 minutes following verification that the UUT received the DAL
147 signal. Determine the maximum of the two readings, T_U .
- 148 7.3.5 Conduct a Unit Demand Response Reset of the UUT between minutes 10 and 11.

149 **7.4 Active Override**

- 150 7.4.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
151 below 70 °F.
- 152 7.4.2 Record the UUT set temperature, T_4 .

- 153 7.4.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer
154 instructions.
- 155 7.4.4 Record the UUT set temperature two times within the 5-minute period following the DAL signal.
156 The first reading shall be taken at an elapsed time between 15 and 45 seconds following
157 verification that the UUT received the DAL signal. The second reading shall be taken at an
158 elapsed time between 4 and 5 minutes following verification that the UUT received the DAL
159 signal. Determine the minimum of the two readings, T_V .
- 160 7.4.5 Override the DAL signal according to manufacturer instructions, at an elapsed time between 5
161 and 10 minutes following verification that the UUT received the DAL signal.
- 162 7.4.6 Record the UUT set temperature two times within the 10-minute period following the activation of
163 the override. The first reading shall be taken at an elapsed time between 15 and 45 seconds
164 following the activation of the override. The second reading shall be taken at an elapsed time
165 between 9 and 10 minutes following activation of the override. Determine the maximum of the two
166 readings, T_A .
- 167 7.4.7 Conduct a Unit Demand Response Reset of the UUT.

168 7.5 Compliance Verification

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

- 170 7.5.1 $85\text{ }^\circ\text{F} \geq T_{S,max} \geq T_{S,min} \geq T_1 + 4\text{ }^\circ\text{F}$
- 171 7.5.2 $85\text{ }^\circ\text{F} = T_H > T_2 \geq 81\text{ }^\circ\text{F}$; otherwise $85\text{ }^\circ\text{F} > T_H \geq T_2 + 4\text{ }^\circ\text{F}$
- 172 7.5.3 $T_U = T_3$
- 173 7.5.4 $T_V \geq T_4 + 4\text{ }^\circ\text{F}$
- 174 7.5.5 $T_A = T_4$

175 8 TEMPORARY APPLIANCE LOAD REDUCTION (TALR) TEST

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

179 8.1 Air Circulation Mode Power Measurement

- 180 8.1.1 Set the UUT to air circulation mode and, for models that have a user-selectable fan speed, adjust
181 the fan speed to the highest setting.
- 182 8.1.2 Run the UUT for 15 minutes.
- 183 8.1.3 Record the electrical power input to the UUT eleven times in the 10-minute period following the
184 15-minute operating period. The first reading shall be taken at an elapsed time between 15 and
185 45 seconds after the start of the 10-minute period. The next nine readings shall be taken at an
186 elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes after the start of the 10-minute period, with a
187 tolerance of +/- 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes and
188 45 seconds after the start of the 10-minute period, with a tolerance of +/- 5 seconds.
- 189 8.1.4 Average all readings to obtain P_{circ} .

190 **8.2 Standard Response**

- 191 8.2.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
192 below 70 °F.
- 193 8.2.2 Run the UUT for 15 minutes and record the electrical power input to the UUT eleven times within
194 the 15-minute period. The first reading shall be taken at an elapsed time between 5 minutes 15
195 seconds and 5 minutes 45 seconds from the start of the 15-minute period. The next nine readings
196 shall be taken at an elapsed time of 6, 7, 8, 9, 10, 11, 12, 13 and 14 minutes from the start of the
197 15-minute period, each with a tolerance of +/- 5 seconds. The last reading shall be taken at an
198 elapsed time of 14 minutes 45 seconds from the start of the 15-minute period, with a tolerance of
199 +/- 5 seconds. Determine the minimum of the eleven electrical power input measurements, $P_{S,on,1}$.
- 200 8.2.3 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
201 manufacturer instructions.
- 202 8.2.4 Record the electrical power input to the UUT eleven times within the 10-minute period following
203 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
204 following verification that the UUT received the TALR signal. The next nine readings shall be
205 taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT
206 received the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken
207 at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
208 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
209 input measurements, $P_{S,off,1}$.
- 210 8.2.5 Continue to run the UUT for 70 minutes after the last reading.
- 211 8.2.6 Record the electrical power input to the UUT eleven times within a 10-minute period following the
212 70-minute operating period. The first reading shall be taken at an elapsed time between 15 and
213 45 seconds from the start of the 10-minute period. The next nine readings shall be taken at an
214 elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes from the start of the 10-minute period, each
215 with a tolerance of +/- 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes
216 45 seconds from the start of the 10-minute period, with a tolerance of +/- 5 seconds. Determine
217 the minimum of the eleven electrical power input measurements, $P_{S,on,2}$.
- 218 8.2.7 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
219 manufacturer instructions.
- 220 8.2.8 Record the electrical power input to the UUT eleven times within the 10-minute period following
221 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
222 following verification that the UUT received the TALR signal. The next nine readings shall be
223 taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT
224 received the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken
225 at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
226 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
227 input measurements, $P_{S,off,2}$.
- 228 8.2.9 Continue to run the UUT for 70 minutes after the last reading.
- 229 8.2.10 Record the electrical power input to the UUT eleven times within a 10-minute period following the
230 70-minute operating period. The first reading shall be taken at an elapsed time between 15 and
231 45 seconds from the start of the 10-minute period. The next nine readings shall be taken at an
232 elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes from the start of the 10-minute period, with a
233 tolerance of +/- 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45
234 seconds from the start of the 10-minute period, with a tolerance of +/- 5 seconds. Determine the
235 minimum of the eleven electrical power input measurements, $P_{S,on,3}$.
- 236 8.2.11 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
237 manufacturer instructions.

238 8.2.12 Record the electrical power input to the UUT eleven times within the 10-minute period following
239 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
240 following verification that the UUT received the TALR signal. The next readings shall be taken at
241 an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT received
242 the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken at an
243 elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
244 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
245 input measurements, $P_{S,off,3}$.

246 **8.3 24-hour Rolling Period Response**

247 8.3.1 Continue to run the UUT until 24 hours have elapsed from the initiation of the TALR signal in
248 section 8.2.3.

249 8.3.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
250 manufacturer instructions.

251 8.3.3 Record the electrical power input to the UUT eleven times within the 10-minute period following
252 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
253 following verification that the UUT received the TALR signal. The next nine readings shall be
254 taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT
255 received the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken
256 at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
257 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
258 input measurements, P_R .

259 8.3.4 Conduct a Unit Demand Response Reset of the UUT.

260 **8.4 Upper Temperature Limit Response**

261 8.4.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
262 above 85 °F.

263 8.4.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
264 manufacturer instructions.

265 8.4.3 Record the electrical power input to the UUT eleven times within the 10-minute period following
266 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
267 following verification that the UUT received the TALR signal. The next nine readings shall be
268 taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT
269 received the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken
270 at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
271 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
272 input measurements, P_U .

273 8.4.4 Conduct a Unit Demand Response Reset of the UUT.

274 **8.5 Active Override**

275 8.5.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
276 below 70 °F.

277 8.5.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
278 manufacturer instructions.

- 279 8.5.3 Record the electrical power input to the UUT six times within the 5-minute period following the
280 TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
281 following verification that the UUT received the TALR signal. The next four readings shall be
282 taken at an elapsed time of 1, 2, 3 and 4 minutes following verification that the UUT received the
283 TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken at an
284 elapsed time of 4 minutes 45 seconds following verification that the UUT received the TALR
285 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the six electrical power input
286 measurements, $P_{A,off}$.
- 287 8.5.4 Override the TALR signal according to manufacturer instructions, 5 minutes (+/-5 seconds)
288 following verification that the UUT received the initial TALR signal.
- 289 8.5.5 Record the electrical power input to the UUT eleven times within the 13-minute period following
290 the override signal. The first reading shall be taken at an elapsed time between 3 minutes 15
291 seconds and 3 minutes 45 seconds following the activation of the override. The next nine
292 readings shall be taken at an elapsed time of 4, 5, 6, 7, 8, 9, 10, 11 and 12 minutes following
293 activation of the override, each with a tolerance of +/- 5 seconds. The last reading shall be taken
294 at an elapsed time of 12 minutes 45 seconds following activation of the override, with a tolerance
295 of +/- 5 seconds. Determine the maximum of the eleven electrical power input measurements,
296 $P_{A,on}$.
- 297 8.5.6 Conduct a Unit Demand Response Reset of the UUT.

298 8.6 Compliance Verification

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

- 300 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
301 8.2
- 302 8.6.2 $P_R < 2 \times P_{circ}$
- 303 8.6.3 $P_U \geq 2 \times P_{circ}$
- 304 8.6.4 $P_{A,off} < 2 \times P_{circ}$
- 305 8.6.5 $P_{A,on} \geq 2 \times P_{circ}$

306 9 REFERENCES

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