



ENERGY STAR® Program Requirements Product Specification for Room Air Conditioners draft Test Method to Validate Demand Response February-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 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.

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

55 4 TEST REQUIREMENTS

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

61 4.1 Delay Appliance Load (DAL) Test

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

63 4.2 Temporary Appliance Load Reduction (TALR) Test

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

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

69 The ambient conditions for the TALR test were selected to ensure continuous compressor operation at a
70 set temperature of $85\text{ }^{\circ}\text{F}$, or the next increment above $85\text{ }^{\circ}\text{F}$. DOE and EPA specified a large tolerance on
71 the TALR ambient temperature to minimize test burden and avoid the need for expensive chamber
72 conditioning equipment.

73 DOE and EPA invite stakeholder comments on the lack of specific test conditions for the DAL test and the
74 test conditions specified for the TALR test.

75 **5 PRE-TEST UUT CONFIGURATION**

76 **5.1 General Configuration**

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

79 **5.2 Communication Setup**

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

82 A) Establish the connection between the Appliance Communication Module and the Utility Equivalent
83 Communication Device via wired or wireless connection depending on the module's capability. A
84 wireless connection is preferred if both are available.

85 B) Ensure that the Appliance Communication Module is properly connected according to manufacturer
86 instructions, and can both receive and send data to the Utility Equivalent Communication Device.

87 **6 MEASUREMENTS**

88 **6.1 Set Temperature**

89 The set temperature of the UUT shall be determined during testing using the consumer interface in
90 accordance with manufacturer instructions. The UUT set temperature may be visible, for example,
91 through a display on the UUT itself or on a mobile or computer application. The UUT set temperature
92 shall not be modified during testing unless explicitly required in this test method.

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

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

101 **6.2 Ambient Temperature**

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

106 **6.3 Elapsed Time**

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

109 **6.4 Electrical Power Input**

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

114 7 DELAY APPLIANCE LOAD (DAL) TEST

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

117 7.1 Standard Response

- 118 7.1.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
119 below 70 °F.
- 120 7.1.2 Record the UUT set temperature, T_1 .
- 121 7.1.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer
122 instructions.
- 123 7.1.4 Record the UUT set temperature nine times within the 4-hour DAL period. The first reading shall
124 be taken at an elapsed time between 15 and 45 seconds following verification that the UUT
125 received the DAL signal. The next seven readings shall be taken at an elapsed time of 30, 60, 90,
126 120, 150, 180 and 210 minutes following verification that the UUT received the DAL signal, each
127 with a tolerance of +/- 1 minute. The final, ninth, reading shall be taken at an elapsed time
128 between 239 and 240 minutes following verification that the UUT received the DAL signal.
129 Determine the minimum of the nine readings, $T_{S, min}$. Determine the maximum of the nine
130 readings, $T_{S, max}$.
- 131 7.1.5 After a period of 24 hours from the start of the DAL signal, initiate step 7.2.1.

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

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

138 7.2 High Temperature Response

- 139 7.2.1 Set the UUT set temperature to the nearest user-selectable temperature increment below 85 °F.
- 140 7.2.2 Record the UUT set temperature, T_2 .
- 141 7.2.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer
142 instructions.
- 143 7.2.4 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_H .
- 148 7.2.5 Conduct a Unit Demand Response Reset of the UUT between minutes 10 and 11.

149 7.3 Upper Temperature Limit

- 150 7.3.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
151 above 85 °F.
- 152 7.3.2 Record the UUT set temperature, T_3 .
- 153 7.3.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer
154 instructions.

155 7.3.4 Record the UUT set temperature two times within the 10-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 9 and 10 minutes following verification that the UUT received the DAL
159 signal. Determine the maximum of the two readings, T_U .

160 7.3.5 Conduct a Unit Demand Response Reset of the UUT between minutes 10 and 11.

161 7.4 Active Override

162 7.4.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
163 below 70 °F.

164 7.4.2 Record the UUT set temperature, T_4 .

165 7.4.3 Initiate a 4-hour DAL signal and verify that the UUT receives the signal according to manufacturer
166 instructions.

167 7.4.4 Record the UUT set temperature two times within the 5-minute period following the DAL signal.
168 The first reading shall be taken at an elapsed time between 15 and 45 seconds following
169 verification that the UUT received the DAL signal. The second reading shall be taken at an
170 elapsed time between 4 and 5 minutes following verification that the UUT received the DAL
171 signal. Determine the minimum of the two readings, T_V .

172 7.4.5 Override the DAL signal according to manufacturer instructions, at an elapsed time between 5
173 and 10 minutes following verification that the UUT received the DAL signal.

174 7.4.6 Record the UUT set temperature two times within the 10-minute period following the activation of
175 the override. The first reading shall be taken at an elapsed time between 15 and 45 seconds
176 following the activation of the override. The second reading shall be taken at an elapsed time
177 between 9 and 10 minutes following activation of the override. Determine the maximum of the two
178 readings, T_A .

179 7.4.7 Conduct a Unit Demand Response Reset of the UUT.

180 **Note:** Consumer override is a key component of the Demand Response Connected Product Criteria in
181 the current ENERGY STAR Program Requirements for Room Air Conditioners, Eligibility Criteria Version
182 4.0. Therefore, DOE and EPA have developed the above series of test in section 7.4 to confirm the
183 override functionality is included and functional.

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

185 7.5 Compliance Verification

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

187 7.5.1 $85\text{ °F} \geq T_{S,max} \geq T_{S,min} \geq T_1 + 4\text{ °F}$

188 7.5.2 $85\text{ °F} = T_H > T_2 \geq 81\text{ °F}$; otherwise $85\text{ °F} > T_H \geq T_2 + 4\text{ °F}$

189 7.5.3 $T_U = T_3$

190 7.5.4 $T_V \geq T_4 + 4\text{ °F}$

191 7.5.5 $T_A = T_4$

192 8 TEMPORARY APPLIANCE LOAD REDUCTION (TALR) TEST

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

196 **8.1 Air Circulation Mode Power Measurement**

197 8.1.1 Set the UUT to air circulation mode and, for models that have a user-selectable fan speed, adjust
198 the fan speed to the highest setting.

199 8.1.2 Run the UUT for 15 minutes.

200 8.1.3 Record the electrical power input to the UUT eleven times in the 10-minute period following the
201 15-minute operating period. The first reading shall be taken at an elapsed time between 15 and
202 45 seconds after the start of the 10-minute period. The next nine readings shall be taken at an
203 elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes after the start of the 10-minute period, with a
204 tolerance of +/- 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes and
205 45 seconds after the start of the 10-minute period, with a tolerance of +/- 5 seconds.

206 8.1.4 Average all readings to obtain P_{circ} .

207 **8.2 Standard Response**

208 8.2.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
209 below 70 °F.

210 8.2.2 Run the UUT for 15 minutes and record the electrical power input to the UUT eleven times within
211 the 15-minute period. The first reading shall be taken at an elapsed time between 5 minutes 15
212 seconds and 5 minutes 45 seconds from the start of the 15-minute period. The next nine readings
213 shall be taken at an elapsed time of 6, 7, 8, 9, 10, 11, 12, 13 and 14 minutes from the start of the
214 15-minute period, each with a tolerance of +/- 5 seconds. The last reading shall be taken at an
215 elapsed time of 14 minutes 45 seconds from the start of the 15-minute period, with a tolerance of
216 +/- 5 seconds. Determine the minimum of the eleven electrical power input measurements, $P_{S,on,1}$.

217 8.2.3 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
218 manufacturer instructions.

219 8.2.4 Record the electrical power input to the UUT eleven times within the 10-minute period following
220 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
221 following verification that the UUT received the TALR signal. The next nine readings shall be
222 taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT
223 received the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken
224 at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
225 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
226 input measurements, $P_{S,off,1}$.

227 8.2.5 Continue to run the UUT for 70 minutes after the last reading.

228 8.2.6 Record the electrical power input to the UUT eleven times within a 10-minute period following the
229 70-minute operating period. The first reading shall be taken at an elapsed time between 15 and
230 45 seconds from the start of the 10-minute period. The next nine readings shall be taken at an
231 elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes from the start of the 10-minute period, each
232 with a tolerance of +/- 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes
233 45 seconds from the start of the 10-minute period, with a tolerance of +/- 5 seconds. Determine
234 the minimum of the eleven electrical power input measurements, $P_{S,on,2}$.

235 8.2.7 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
236 manufacturer instructions.

237 8.2.8 Record the electrical power input to the UUT eleven times within the 10-minute period following
238 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
239 following verification that the UUT received the TALR signal. The next nine readings shall be
240 taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT
241 received the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken
242 at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
243 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
244 input measurements, $P_{S,off,2}$.

245 8.2.9 Continue to run the UUT for 70 minutes after the last reading.

246 8.2.10 Record the electrical power input to the UUT eleven times within a 10-minute period following the
247 70-minute operating period. The first reading shall be taken at an elapsed time between 15 and
248 45 seconds from the start of the 10-minute period. The next nine readings shall be taken at an
249 elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes from the start of the 10-minute period, with a
250 tolerance of +/- 5 seconds. The last reading shall be taken at an elapsed time of 9 minutes 45
251 seconds from the start of the 10-minute period, with a tolerance of +/- 5 seconds. Determine the
252 minimum of the eleven electrical power input measurements, $P_{S,on,3}$.

253 8.2.11 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
254 manufacturer instructions.

255 8.2.12 Record the electrical power input to the UUT eleven times within the 10-minute period following
256 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
257 following verification that the UUT received the TALR signal. The next readings shall be taken at
258 an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT received
259 the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken at an
260 elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
261 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
262 input measurements, $P_{S,off,3}$.

263 8.3 24-hour Rolling Period Response

264 8.3.1 Continue to run the UUT until 24 hours have elapsed from the initiation of the TALR signal in
265 section 8.2.3.

266 8.3.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
267 manufacturer instructions.

268 8.3.3 Record the electrical power input to the UUT eleven times within the 10-minute period following
269 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
270 following verification that the UUT received the TALR signal. The next nine readings shall be
271 taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT
272 received the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken
273 at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
274 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
275 input measurements, P_R .

276 8.3.4 Conduct a Unit Demand Response Reset of the UUT.

277 8.4 Upper Temperature Limit Response

278 8.4.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
279 above 85 °F.

280 8.4.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
281 manufacturer instructions.

282 8.4.3 Record the electrical power input to the UUT eleven times within the 10-minute period following
283 the TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
284 following verification that the UUT received the TALR signal. The next nine readings shall be
285 taken at an elapsed time of 1, 2, 3, 4, 5, 6, 7, 8 and 9 minutes following verification that the UUT
286 received the TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken
287 at an elapsed time of 9 minutes 45 seconds following verification that the UUT received the TALR
288 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the eleven electrical power
289 input measurements, P_U .

290 8.4.4 Conduct a Unit Demand Response Reset of the UUT.

291 8.5 Active Override

292 8.5.1 Set the UUT set temperature to the nearest user-selectable temperature increment equal to or
293 below 70 °F.

294 8.5.2 Initiate a 10-minute TALR signal and verify that the UUT receives the signal according to
295 manufacturer instructions.

296 8.5.3 Record the electrical power input to the UUT six times within the 5-minute period following the
297 TALR signal. The first reading shall be taken at an elapsed time between 15 and 45 seconds
298 following verification that the UUT received the TALR signal. The next four readings shall be
299 taken at an elapsed time of 1, 2, 3 and 4 minutes following verification that the UUT received the
300 TALR signal, each with a tolerance of +/- 5 seconds. The last reading shall be taken at an
301 elapsed time of 4 minutes 45 seconds following verification that the UUT received the TALR
302 signal, with a tolerance of +/- 5 seconds. Determine the maximum of the six electrical power input
303 measurements, $P_{A,off}$.

304 8.5.4 Override the TALR signal according to manufacturer instructions, 5 minutes (+/-5 seconds)
305 following verification that the UUT received the initial TALR signal.

306 8.5.5 Record the electrical power input to the UUT eleven times within the 13-minute period following
307 the override signal. The first reading shall be taken at an elapsed time between 3 minutes 15
308 seconds and 3 minutes 45 seconds following the activation of the override. The next nine
309 readings shall be taken at an elapsed time of 4, 5, 6, 7, 8, 9, 10, 11 and 12 minutes following
310 activation of the override, each with a tolerance of +/- 5 seconds. The last reading shall be taken
311 at an elapsed time of 12 minutes 45 seconds following activation of the override, with a tolerance
312 of +/- 5 seconds. Determine the maximum of the eleven electrical power input measurements,
313 $P_{A,on}$.

314 8.5.6 Conduct a Unit Demand Response Reset of the UUT.

315 **Note:** Consumer override is a key component of the Demand Response Connected Product Criteria in
316 the current ENERGY STAR Program Requirements for Room Air Conditioners, Eligibility Criteria Version
317 4.0. Therefore, DOE and EPA have developed the above series of test in section 8.5 to confirm the
318 override functionality is included and functional.

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

320 8.6 Compliance Verification

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

- 322 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
323 8.2
- 324 8.6.2 $P_R < 2 \times P_{circ}$
- 325 8.6.3 $P_U \geq 2 \times P_{circ}$
- 326 8.6.4 $P_{A,off} < 2 \times P_{circ}$
- 327 8.6.5 $P_{A,on} \geq 2 \times P_{circ}$

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

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

333 9 REFERENCES

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