



ENERGY STAR® Program Requirements Product Specification for Uninterruptible Power Supplies (UPSs)

Final Draft Test Method Rev. Nov-2017

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Eligibility Criteria for Uninterruptible Power Supplies (UPSs).

2 APPLICABILITY

The following test method is applicable to all products eligible for qualification under ENERGY STAR Eligibility Criteria for UPSs, including:

Product Type	Test Method
UPSs capable of operating at 115 V and 60 Hz that use NEMA 1-15P or 5-15P plug	Uniform Test Method for Measuring the Energy Consumption of Battery Chargers incorporated in Appendix Y to Subpart B of 10 CFR 430, Section 4: Testing Requirements for Uninterruptible Power Supplies
All other UPSs	ENERGY STAR Version 2.0 Test Method for Uninterruptible Power Supplies, Rev. March-2017.

3 TEST SETUP

A) Test Setup and Instrumentation: Unless otherwise specified within this Test Method, the test setup and instrumentation for all portions of this method shall be in accordance with the following:

- 1) For Ac-output UPSs, International Electrotechnical Commission (IEC) standard:
 - a) IEC 62040-3:2011, Ed. 2.0, *Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements*, Section J.2.
- 2) For High-voltage Dc-output Datacenter UPSs (output voltage greater than 60 V), International Electrotechnical Commission (IEC) standard:
 - a) IEC 62040-5-3:2016; *Uninterruptible power systems (UPS) – Part 5-3: DC output UPS – Performance and test requirements*, Annex F.
- 3) For Low-voltage Dc-output UPSs/Rectifiers (output voltage less than or equal to 60 V), Alliance for Telecommunications Industry Solutions (ATIS) standards:
 - a) ATIS-0600015.2013, *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting – General Requirements*; and
 - b) ATIS-0600015.04.2010, *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting DC Power Plant – Rectifier Requirements*.

Note:

The requirement in Section 5.4 of ATIS-0600015.2013, which states “DC power

39 sources used to provide power to the equipment under test shall be capable of
40 providing a minimum of 1.5 times the power rating of the equipment under test," is
41 optional for ENERGY STAR testing.

42 The requirement in Section 6.2 of ATIS-0600015.04.2010, which states the Unit
43 Under Test (UUT) shall be evaluates with "a power source with a rating of at
44 least 2X the maximum input power rating of the rectifier," is optional for ENERGY
45 STAR testing.

46 **Note:** EPA has clarified that the boundary between High-voltage and Low-voltage Dc-output UPSs is
47 60 V, consistent with the Definitions Section of the Eligibility Criteria.

- 48
- 49 B) The UUT shall be tested in "as-shipped" configuration, with the following exceptions:
- 50 1) Any dc output port(s) of the UUT that provide less than 90% of the rated output power must
51 remain unloaded during testing, unless that would result in all ports unloaded.
- 52 2) Any feature unrelated to maintaining the energy storage system at full charge or delivery of
53 load power (e.g., LCD display) shall be switched off. If it is not possible to switch such
54 features off, they shall be set to their lowest power-consuming mode during the test.
- 55 3) If the UPS takes any physically separate connectors or cables not required for maintaining
56 the energy storage system at full charge or delivery of load power but associated with other
57 features (such as serial or USB connections, Ethernet, etc.), these connectors or cables
58 shall be left disconnected during the test.
- 59 4) Any manual on-off switches specifically associated with maintaining the energy storage
60 system at full charge or delivery of load power shall be switched on for the duration of the
61 test.
- 62 C) Ac-input Power: The UUT shall be connected to the first (highest) rated voltage and rated
63 frequency combination specified in Table 1. If two frequencies are provided in a given row, the
64 manufacturer may specify which frequency shall be used for testing.
- 65

66 **Table 1: Input Supply Requirements**

Voltage and Precedence	Frequency
1. 600Δ V ac	60 Hz
2. 600Y/346 V ac	60 Hz
3. 480Δ V ac	60 Hz
4. 480Y/277 V ac	60 Hz
5. 415Δ V ac	60 Hz
6. 415Y/240 V ac	60 Hz
7. 400Δ V ac	50 Hz
8. 400Y/230 V ac	50 Hz
9. 380Y/220 V Ac	50 or 60 Hz
10. 230 V ac	50 or 60 Hz
11. 208Δ V ac	60 Hz

12. 208Y/120 V ac	60 Hz
13. 200 V ac	50 or 60 Hz
14. 120 V ac	60 Hz
15. 115 V ac	50 or 60 Hz
16. 100 V ac	50 or 60 Hz

68 1) UUTs that are not compatible with any of the combinations listed in Table 1 shall be connected
69 to the highest rated voltage and frequency combination. The test voltage and frequency used for
70 the test shall be reported.

71
72 D) Ac-output Power: For Ac-output UPSs, the output voltage and frequency of the UUT shall have
73 the same characteristics as the input voltage, specified in Table 1, above, and Section J.2 of
74 IEC standard 62040-3, Ed. 2.0.

75
76 1) UUTs that have an output voltage different from the input voltage shall be tested at the
77 highest compatible output voltage. The voltage and frequency used for the test shall be
78 reported.

79
80 E) Dc-output Power: For Dc-output UPSs/Rectifiers, the output voltage of the UUT shall be the
81 first applicable voltage specified in Table 2, from top to bottom. The voltage used for the test
82 shall be reported.

83 **Table 2: Dc-output Power Requirements and Precedence**

Nominal Voltage and Precedence	Voltage for Test ¹	Voltage Tolerance
1. 380 V dc	418 V dc	+/- 1 %
2. 48 V dc	53 V dc	+/- 1 %
3. 60 V dc	66 V dc	+/- 1 %
4. 24 V dc	26 V dc	+/- 1 %
5. USB Type C	20 V dc	+/- 1 %
6. 575 V dc	595 V dc	+/- 1 %

85
86 F) Measurement Accuracy:

- 87
88
89 1) Power measurements with a value greater than or equal to 2 W shall be made with an
90 uncertainty of less than or equal to 0.5% at the 95% confidence level.
91
92 2) Power measurements with a value less than 2 W shall be made with an uncertainty of less
93 than or equal to 0.01 W at the 95% confidence level.
94
95 3) Output power measurement shall be taken as close to the output of the UUT as is feasible
96 to ensure compliance with accuracy requirements specified in the referenced test methods.
97

¹ Expected voltage for a fully charged battery

98 G) Relative Humidity: Relative humidity shall be within the range specified by the manufacturer.

99 **Note:** EPA has revised the humidity range to that specified by the manufacturer, rather than the
100 originally proposed 0–100%, which may fall outside of UUT specifications.

101 **4 TEST CONDUCT**

102 **4.1 UPS Operating Mode Conditions**

103 If the UUT can operate in two or more distinct normal modes, conduct all parts of the test and report all
104 parameters listed in the test reporting template in:

- 105 • The lowest input dependency, and
- 106 • The highest input dependency, as specified in the ENERGY STAR Eligibility Criteria
107 for UPSs.

108 If applicable, the UUT shall be tested in the highest efficiency sub-mode of each tested normal mode.
109

110 **4.2 ENERGY STAR Guidance for Implementation of IEC 62040-3, Ed. 2.0²**

111 A) The reference test load defined in IEC 62040-3, Ed. 2.0 Section 3.3.5 shall be a resistive test load.

112 B) Modular UPSs with output power that varies depending on the number of modules installed shall
113 be tested twice, at both the vendor specified minimum and maximum non-redundant (i.e., N+0)
114 configurations.

115 1) For Low-voltage Dc-output UPSs/Rectifiers, this test method shall take precedence over the
116 requirements specified in Section 5.10 of the ATIS -0600015.2013 standard.³

117 C) Modular UPSs shall be tested with redundant components (e.g., fans, controllers, etc.) for the
118 vacant module slots functioning according to the UUT's as-shipped default behavior.

119 D) Back-feeding the source may be used in place of a test load during testing of UPS systems larger
120 than 100 kW output, provided that an output power factor greater than 0.99 is maintained at all
121 times.

122 E) Energy Storage System: The UPS shall not be modified or adjusted to disable energy storage
123 charging features, with the following exceptions.

124 1) If the energy storage system is able to be disconnected by physical means or by using
125 default controls while maintaining normal operation, and the user manual or other publicly
126 available documents do not advise against disconnecting it, the UPS shall be tested with
127 the energy storage system disconnected.⁴

128 2) The UPS may be adjusted to disable any alarms, indications, or default detection mechanisms
129 that may result from disconnecting the energy storage system, as long as the controls
130 necessary to do so are natively present on the UPS or are included in end user software.

131 3) If unable to disconnect the energy storage system as instructed in Sections 4.2.G.1 and
132 4.2.G.2, the energy storage system shall store maximum energy and the transfer of energy to
133

² This guidance also applies to Dc-output UPSs.

³ The ATIS-0600015.2013 specifies that modular Dc-Output UPSs/Rectifiers may be tested on a per-module basis.

⁴ The ATIS standard does not specify the disconnection of the energy storage system. Therefore, all UPSs, including Dc-output UPSs/Rectifiers, shall follow this provision.

- 146 and from the energy storage system shall be minimized during the test.
 147
 148 a) For battery operated UPSs, to ensure the battery is fully charged, perform the following
 149 steps:
- 150 i. For UPSs that have an indicator to show that the battery is fully charged,
 151 continue charging for an additional 5 hours after the fully charged indication is
 152 present.
 - 153 ii. If there is no state of charge indicator, but the manufacturer's instructions provide a
 154 time estimate for when charging this battery or this capacity of battery should be
 155 complete, continue charging for an additional 5 hours after the manufacturer's
 156 estimate.
 - 157 iii. If there is no indicator and no time estimate in the instructions, but the charging current
 158 is stated on the UPS or in the instructions, terminate charging 1 hour after the
 159 calculated test duration or, if none of the above applies, the duration shall be 24 hours.
 160
- 161 b) For battery operated UPSs, if the UPS is shipped with a battery, that battery shall be used
 162 for testing. Otherwise, the manufacturer may select a battery for testing. Details regarding
 163 the selected battery shall be included in the PPDS, if available, or publicly available
 164 documents and documented in the test reporting template. These batteries are not
 165 required to ship with the UPS.
 166
 167

168 5 TEST PROCEDURES FOR ALL PRODUCTS

- 169
 170 A) Required Calculations: Equations 1 and 2 shall be used when calculating the UUT's average
 171 power and efficiency:
 172

173 Equation 1: Calculation of Average Power

$$174 \quad P_{AVG} = \frac{E_{TOT}}{t}$$

175
 176
 177 *Where:*

- 178 ▪ P_{AVG} is the average power in watts.
- 179 ▪ E_{TOT} is the total energy in watt-hours.
- 180 ▪ t is the length of the measurement in hours.

181 Equation 2: Calculation of Efficiency

$$182 \quad Eff = \frac{P_{AVG_OUT}}{P_{AVG_IN}}$$

183
 184
 185 *Where:*

- 186 ▪ Eff is the UPS efficiency.
- 187 ▪ P_{AVG_OUT} is the average output power in watts.
- 188 ▪ P_{AVG_IN} is the average input power in watts.

- 189
 190
 191 B) Steady-state: The UPS and load shall have been operated for a sufficient length of time to reach
 192 thermal stability. Allow the UUT to stabilize for 125% of the manufacturer-specified stabilization
 193 time, as instructed in Appendix J of IEC 62040-3, Ed. 2.0. During the final 20 minutes of the

194 stabilization period, at the 100% loading point, perform the following steady-state check, in which
195 the difference between the two efficiency calculations shall be less than one percent:

- 196
- 197 1) Simultaneously measure the UUT's accumulated input and output energy in watt-hours (Wh)
198 for at least 5 minutes.
 - 199 2) Calculate the UUT's average input and output power in watts (W) using Equation 1.
 - 200 3) Calculate the UUT's efficiency, Eff_1 , using Equation 2.
 - 201 4) Wait a minimum of 10 minutes.
 - 202 5) Repeat steps 1 to 3 to calculate another efficiency value, Eff_2 .
 - 203 6) Equation 3 shall be used to determine if the UUT is at steady-state. If the percent difference of
204 Eff_1 and Eff_2 , as described in Equation 3, is less than one percent, the UUT is at steady-state.
- 205

206 **Equation 3: Calculation of Efficiency Variation for Determination of Steady-state**

207
$$\text{Percent Difference} = \frac{|Eff_1 - Eff_2|}{\text{Average}(Eff_1, Eff_2)}$$

- 208
- 209 7) If the percent difference is greater than or equal to one percent, the UUT is not at steady-state.
210 Repeat steps 4 to 6 until the UUT is at steady-state. Record the appropriate values in the test
211 reporting template.
- 212

213 C) Efficiency Measurements: Input and output power measurements for efficiency calculations shall
214 be performed on the UUT according to Section J.3 of IEC standard 62040-3, Ed. 2.0, with the
215 following exceptions.

- 216
- 217 1) Test the UUT at the following reference test load conditions, in the specified order:
 - 218 a) Ac-output UPSs and high-voltage Dc-output UPSs: 100%, 75%, 50%, 25%, and 0% of the
219 rated output power.
 - 220 b) Low-voltage Dc-output UPSs/Rectifiers: 80%, 70%, 60%, 50%, 40%, 30%, 0% of the rated
221 output power.
- 222

223 *Note*: For the 0% loading condition (i.e., the test load disconnected, but output inverter
224 operational for Ac-output UPS), measure only at the input to the UUT.

225

- 226
- 227 2) The test shall be performed at each of the reference test loads by simultaneously measuring
228 the UUT's total input and output energy in Wh over a 15 minute test period. The total energy
229 accumulation rate shall be at least 1 Hz. Calculate the UUT's average input power and output
230 power for the period using Equation 1, and the UUT's efficiency using Equation 2.
 - 231 3) Measure and record all the applicable parameters listed in the test reporting template for each
232 Ac-output/Dc-output UPS test performed. For Ac-output UPSs, also record the input
233 dependency characteristic (AAA) in the tested modes, as specified in Section 5.3.4 of IEC
234 standard 62040-3, Ed. 2.0.
- 235

236

237 D) InputPowerFactorMeasurements: Measure and report the input power factor of the UUT per Section
238 6.4.1.5 of IEC standard 62040-3, Ed. 2.0, for each mode at 100% of the reference test load.⁵⁵

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240

241 6 REFERENCES

- 242
- 243 A) 10 CFR 430 Subpart B Appendix Y, *Uniform Test Method for Measuring the Energy*

⁵ Neither the ATIS-0600015.2013 nor the ATIS-0600015.04.2010 standard specifies requirements for testing input power factor; therefore, the provisions contained in section 6.4.1.5 of IEC standard 62040-3 shall be used for testing the input power factor of Dc-output UPSs/Rectifiers.

- 244 *Consumption of Battery Chargers*
- 245 B) ATIS-0600015.04.2010, *Energy Efficiency for Telecommunication Equipment: Methodology*
246 *for Measurement and Reporting DC Power Plant – Rectifier Requirements*. January 1, 2010.
247
- 248 C) ATIS-0600015.2013, *Energy Efficiency for Telecommunication Equipment: Methodology*
249 *for Measurement and Reporting – General Requirements*. May 6, 2013.
250
- 251 D) IEC 62040-3:2011, Ed. 2.0, *Uninterruptible power systems (UPS) - Part 3: Method of specifying*
252 *the performance and test requirements*, Section J.2. March 14, 2011.
253
- 254 E) IEC 62040-5-3: 2016, Ed. 1, *Uninterruptible power systems (UPS) - Part 5-3: DC output UPS -*
255 *Performance and test requirements*, Annex F. October 26, 2016.
256
- 257 F) DOE Appendix Y to Subpart B of 10 CFR 430, Section 4: Testing Requirements for
258 Uninterruptible Power Supplies.