



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

Draft 2 Test Method Rev. Sep-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, 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, 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 updated references to ATIS standards throughout the test method to reflect the latest
47 versions of those standards.

48 EPA is interested in incorporating into scope UPS devices that distribute power over USB. This will
49 require specifying how many of available ports to use, what voltage(s) to utilize, how power
50 consumption should be distributed across the ports, and may include guidance on measuring power.
51 EPA welcomes feedback from stakeholders on the potential of these products and required testing
52 language.

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54 B) The UUT shall be tested in "as-shipped" configuration, with the following exceptions:

- 55 1) Any dc output port(s) of the UUT that provide less than 90% of the rated output power must
56 remain unloaded during testing, unless that would result in all ports unloaded.
- 57 2) Any feature unrelated to maintaining the energy storage system at full charge or delivery of
58 load power (e.g., LCD display) shall be switched off. If it is not possible to switch such
59 features off, they shall be set to their lowest power-consuming mode during the test.
- 60 3) If the UPS takes any physically separate connectors or cables not required for maintaining
61 the energy storage system at full charge or delivery of load power but associated with other
62 features (such as serial or USB connections, Ethernet, etc.), these connectors or cables
63 shall be left disconnected during the test.
- 64 4) Any manual on-off switches specifically associated with maintaining the energy storage
65 system at full charge or delivery of load power shall be switched on for the duration of the
66 test.

67 **Note:** EPA originally proposed Section 3.B to clarify the state of the UPS during testing, which was
68 harmonized with 10 CFR 430 Subpart B Appendix Y. EPA has further clarified that 3.B)1) applies only
69 to dc outputs that are capable of providing less than 90% of the rated output power (i.e., auxiliary
70 outputs), unless all ports meet this criterion (e.g., in the case of a UPS with only USB ports to provide
71 power to loads).

72 C) Ac-input Power: The UUT shall be connected to the first (highest) rated voltage and rated
73 frequency combination specified in Table 1. If two frequencies are provided in a given row, the
74 manufacturer may specify which frequency shall be used for testing.

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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

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

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

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86 1) UUTs that have an output voltage different from the input voltage shall be tested at the
87 highest compatible output voltage. The voltage and frequency used for the test shall be
88 reported.

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

93 **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%
575 V dc	595 V	+/- 1 %

95 **Note:** EPA understands that not all USB Type-C outputs may support the USB Power Delivery
96 Specification, and may therefore operate at 5 V rather than the 20 V indicated in the table above.

¹ Expected voltage for a fully charged battery

97 However, since the 5 V outputs can carry between 1/20 and 1/4 of the power of the 20 V outputs, EPA
98 expects them to be implemented in fewer products and carry less total power, and therefore be less of
99 a focus for efficiency testing.

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F) Measurement Accuracy:

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

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Note: EPA is proposing to clarify that when measuring the output power, the measurement shall be taken as close to the output as feasible to avoid capturing losses in the output cable, which can be significant. EPA also proposes to include measurement accuracy requirements consistent with IEC 62040-3 and IEC 62040-5-3, which require 0.5% uncertainty at the 95% confidence level. Subsection 3.F)2) is intended to relax this requirement at low power levels, consistent with IEC 62301 Measurement of Standby Power and other ENERGY STAR test methods.

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G) Relative Humidity: Relative humidity shall be between 0% and 100%.

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Note: Due to the limited impact of relative humidity on thermal conductivity of air over the required temperature ranges around 25 °C specified in the IEC 62040-3 and ATIS-0600015.2013 test methods, EPA proposes to explicitly remove the humidity requirement.

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4 TEST CONDUCT

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4.1 UPS Operating Mode Conditions

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

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

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

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

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

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

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- 1) For Low-voltage Dc-output UPSs/Rectifiers, this test method shall take precedence over the

² This guidance also applies to Dc-output UPSs.

147 requirements specified in Section 5.10 of the ATIS -0600015.2013 standard.³

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

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

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

158 **Note:** EPA proposes to combine former sections 4.2.E and 4.2.F to keep all energy storage system
159 requirements in one place and clarify the relationships between them.

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

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

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170 3) If unable to disconnect the energy storage system as instructed in Sections 4.2.G.1 and
171 4.2.G.2, the energy storage system shall store maximum energy and the transfer of energy to
172 and from the energy storage system shall be minimized during the test.

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174 a) For battery operated UPSs, to ensure the battery is fully charged, perform the following
175 steps:

176 i. For UPSs that have an indicator to show that the battery is fully charged,
177 continue charging for an additional 5 hours after the fully charged indication is
178 present.

179 ii. If there is no state of charge indicator, but the manufacturer's instructions provide a
180 time estimate for when charging this battery or this capacity of battery should be
181 complete, continue charging for an additional 5 hours after the manufacturer's
182 estimate.

183 iii. If there is no indicator and no time estimate in the instructions, but the charging current
184 is stated on the UPS or in the instructions, terminate charging 1 hour after the
185 calculated test duration or, if none of the above applies, the duration shall be 24 hours.

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187 b) For battery operated UPSs, if the UPS is shipped with a battery, that battery shall be used
188 for testing. Otherwise, the manufacturer may select a battery for testing. Details regarding
189 the selected battery shall be included in the PPDS, if available, or publicly available
190 documents and documented in the test reporting template. These batteries are not
191 required to ship with the UPS.

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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.

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5 TEST PROCEDURES FOR ALL PRODUCTS

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196 A) Required Calculations: Equations 1 and 2 shall be used when calculating the UUT’s average
197 power and efficiency:

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Equation 1: Calculation of Average Power

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

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Where:

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▪ P_{AVG} is the average power in watts.

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▪ E_{TOT} is the total energy in watt-hours.

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▪ t is the length of the measurement in hours.

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Equation 2: Calculation of Efficiency

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

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Where:

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▪ Eff is the UPS efficiency.

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▪ P_{AVG_OUT} is the average output power in watts.

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▪ P_{AVG_IN} is the average input power in watts.

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B) Steady-state: The UPS and load shall have been operated for a sufficient length of time to reach thermal stability. Allow the UUT to stabilize for 125% of the manufacturer-specified stabilization time, as instructed in Appendix J of IEC 62040-3, Ed. 2.0. During the final 20 minutes of the stabilization period, at the 100% loading point, perform the following steady-state check, in which the difference between the two efficiency calculations shall be less than one percent:

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1) Simultaneously measure the UUT’s accumulated input and output energy in watt-hours (Wh) for at least 5 minutes.

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2) Calculate the UUT’s average input and output power in watts (W) using Equation 1.

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3) Calculate the UUT’s efficiency, Eff_1 , using Equation 2.

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4) Wait a minimum of 10 minutes.

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5) Repeat steps 1 to 3 to calculate another efficiency value, Eff_2 .

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6) Equation 3 shall be used to determine if the UUT is at steady-state. If the percent difference of Eff_1 and Eff_2 , as described in Equation 3, is less than one percent, the UUT is at steady-state.

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

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

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

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

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- 243 1) Test the UUT at the following reference test load conditions, in the specified order:
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245 a) Ac-output UPSs and high-voltage Dc-output UPSs: 100%, 75%, 50%, 25%, and 0% of the
246 rated output power.
247 b) Low-voltage Dc-output UPSs/Rectifiers: 80%, 70%, 60%, 50%, 40%, 30%, 0% of the rated
248 output power.
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250 *Note:* For the 0% loading condition (i.e., the test load disconnected, but output inverter
251 operational for Ac-output UPS), measure only at the input to the UUT.
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253 2) The test shall be performed at each of the reference test loads by simultaneously measuring
254 the UUT's total input and output energy in Wh over a 15 minute test period. The total energy
255 accumulation rate shall be at least 1 Hz. Calculate the UUT's average input power and output
256 power for the period using Equation 1, and the UUT's efficiency using Equation 2.
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258 3) Measure and record all the applicable parameters listed in the test reporting template for each
259 Ac-output/Dc-output UPS test performed. For Ac-output UPSs, also record the input
260 dependency characteristic (AAA) in the tested modes, as specified in Section 5.3.4 of IEC
261 standard 62040-3, Ed. 2.0.
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263 D) InputPowerFactorMeasurements: Measure and report the input power factor of the UUT per Section
264 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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267 6 REFERENCES

- 268 A) 10 CFR 430 Subpart B Appendix Y, *Uniform Test Method for Measuring the Energy*
269 *Consumption of Battery Chargers*
270
271 B) ATIS-0600015.04.2010, *Energy Efficiency for Telecommunication Equipment: Methodology*
272 *for Measurement and Reporting DC Power Plant – Rectifier Requirements*. January 1, 2010.
273
274 C) ATIS-0600015.2013, *Energy Efficiency for Telecommunication Equipment: Methodology*
275 *for Measurement and Reporting – General Requirements*. May 6, 2013.
276
277 D) IEC 62040-3:2011, Ed. 2.0, *Uninterruptible power systems (UPS) - Part 3: Method of specifying*
278 *the performance and test requirements*, Section J.2. March 14, 2011.
279
280 E) IEC 62040-5-3: 2016, Ed. 1, *Uninterruptible power systems (UPS) - Part 5-3: DC output UPS -*
281 *Performance and test requirements*, Annex F. October 26, 2016.
282
283 F) DOE Appendix Y to Subpart B of 10 CFR 430, Section 4: Testing Requirements for
284 Uninterruptible Power Supplies.
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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.