



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

Draft 1 Test Method Rev. Mar-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.

Note: The scope of the U.S. Department of Energy (DOE) test method, codified in Appendix Y to Subpart B of 10 CFR 430, is limited to “battery chargers [including UPSs] operating at either DC or United States AC line voltage (115V at 60Hz) . . . that utilize the standardized National Electrical Manufacturer Association (NEMA) plug, 1-15P or 5-15P, as specified in ANSI/NEMA WD 6-2016” and that “have an AC output”. EPA proposes that all other UPSs be tested to the ENERGY STAR test method, which does not require a battery connection, and thus the UUT definition would not include the battery. This would allow eligible products meeting the final Version 2.0 specification requirements to remain certified without requiring re-testing.

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.

38 **Note:** EPA is proposing a separate reference test method for high-voltage Dc-output UPSs. This test
39 method was developed specifically for data center Dc-output UPSs and is based on the IEC 62040-3
40 Annex J test method for Ac-output data center UPSs. Low-voltage Dc-output UPSs/Rectifiers used for
41 Telecom applications will continue to use the Alliance for Telecommunications Industry Solutions
42 (ATIS) test method.

43 EPA has proposed the test method reference and a separate requirement in the Draft 1, Version 2.0
44 specification to provide clear guidance were these products to become more widely available in the
45 future.

- 46 3) For Low-voltage Dc-output UPSs/Rectifiers, Alliance for Telecommunications Industry
47 Solutions (ATIS) standards:
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49 a) ATIS-0600015.2009, *Energy Efficiency for Telecommunication Equipment: Methodology
50 for Measurement and Reporting – General Requirements*; and
51 b) ATIS-0600015.04.2010, *Energy Efficiency for Telecommunication Equipment:
52 Methodology for Measurement and Reporting DC Power Plant – Rectifier Requirements*.
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54 *Note:*

55 The requirement in Section 5.4 of ATIS-0600015.2009, which states “DC power
56 sources used to provide power to the equipment under test shall be capable of
57 providing a minimum of 1.5 times the power rating of the equipment under test,” is
58 optional for ENERGY STAR testing.

59 The requirement in Section 6.2 of ATIS-0600015.04.2010, which states the Unit
60 Under Test (UUT) shall be evaluates with “a power source with a rating of at
61 least 2X the maximum input power rating of the rectifier,” is optional for ENERGY
62 STAR testing.
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- 64 B) The UUT shall be tested in “as-shipped” configuration, with the following exceptions:
65 1) All DC output ports(s) of the UUT must remain unloaded during testing
66 2) Any feature unrelated to maintaining the energy storage system at full charge or delivery of
67 load power (e.g., LCD display) shall be switched off. If it is not possible to switch such
68 features off, they shall be set to their lowest power-consuming mode during the test.
69 3) If the UPS takes and physically separate connectors or cables not required for maintaining
70 the energy storage system at full charge or delivery of load power but associated with other
71 features (such as serial or USB connections, Ethernet, etc.), these connectors or cables
72 shall be left disconnected during the test.
73 4) Any manual on-off switches specifically associated with maintaining the energy storage
74 system at full charge or delivery of load power shall be switched on for the duration of the
75 test.

76 **Note:** EPA proposes 3.B above to clarify the state of the UPS during testing. It is harmonized with 10
77 CFR 430 Subpart B Appendix Y.

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

Voltage	Frequency
600 Δ V ac	60 Hz
600Y/346 V ac	60 Hz
480 Δ V ac	60 Hz
480Y/277 V ac	60 Hz
415 Δ V ac	60 Hz
415Y/240 V ac	60 Hz
400 Δ V ac	50 Hz
400Y/230 V ac	50 Hz
380Y/220 V Ac	50 or 60 Hz
230 V ac	50 or 60 Hz
208 Δ V ac	60 Hz
208Y/120 V ac	60 Hz
200 V ac	50 or 60 Hz
120 V ac	60 Hz
115 V ac	50 or 60 Hz
100 V ac	50 or 60 Hz

- 84 1) UUTs that are not compatible with any of the combinations listed in Table 1 shall be connected
85 to the highest rated voltage and frequency combination. The test voltage and frequency used for
86 the test shall be reported.
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- 88 D) Ac-output Power: For Ac-output UPSs, the output voltage and frequency of the UUT shall have
89 the same characteristics as the input voltage, specified in Table 1, above, and Section J.2 of
90 IEC standard 62040-3, Ed. 2.0.
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- 92 1) UUTs that have an output voltage different from the input voltage shall be tested at the
93 highest compatible output voltage. The voltage and frequency used for the test shall be
94 reported.
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- 96 E) Dc-output Power: For Dc-output UPSs/Rectifiers, the output voltage of the UUT shall be the
97 first applicable voltage specified in Table 2, from top to bottom. The voltage used for the test
98 shall be reported.

Table 2: Dc-output Power Requirements and Precedence

Nominal Voltage	Voltage for Test ¹	Voltage Tolerance
380 V dc	418 V dc	+/- 1 %
48 V dc	53 V dc	+/- 1 %
60 V dc	66 V dc	+/- 1 %
24 V dc	26 V dc	+/- 1 %
575 V dc	595 V dc	+/- 1 %

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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 requirements specified in Section 5.10 of the ATIS -0600015.2009 standard.³

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

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

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E) The UPS shall not be modified or adjusted to disable energy storage charging features.

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¹ Expected voltage for a fully charged battery

² This guidance also applies to Dc-output UPSs.

³ The ATIS-0600015.2009 specifies that modular Dc-Output UPSs/Rectifiers may be tested on a per-module basis.

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Note: EPA is proposing to remove Section 3.5, Standard Information Reportion Requirements from the Version 2.0 specification, and is therefore removing the Power and Performance Data Sheet (PPDS) reporting requirement from the test method.

F) Energy Storage System:

- 1) If the energy storage system is able to be disconnected by physical means or by using default controls while maintaining normal operation, and the user manual or other publicly available documents do not advise against disconnecting it, the UPS shall be tested with the energy storage system disconnected.⁴
- 2) The UPS may be adjusted to disable any alarms, indications, or default detection mechanisms that may result from disconnecting the energy storage system, as long as the controls necessary to do so are natively present on the UPS or are included in end user software.
- 3) If unable to disconnect the energy storage system as instructed in Sections 4.2.G.1 and 4.2.G.2, the energy storage system shall store maximum energy and the transfer of energy to and from the energy storage system shall be minimized during the test.
 - a) For battery operated UPSs, to ensure the battery is fully charged, perform the following steps:
 - i. For UPSs that have an indicator to show that the battery is fully charged, continue charging for an additional 5 hours after the fully charged indication is present.
 - ii. If there is no state of charge indicator, but the manufacturer’s instructions provide a time estimate for when charging this battery or this capacity of battery should be complete, continue charging for an additional 5 hours after the manufacturer’s estimate.
 - iii. If there is no indicator and no time estimate in the instructions, but the charging current is stated on the UPS or in the instructions, terminate charging 1 hour after the calculated test duration or, if none of the above applies, the duration shall be 24 hours.
 - b) For battery operated UPSs, if the UPS is shipped with a battery, that battery shall be used for testing. Otherwise, the manufacturer may select a battery for testing. Details regarding the selected battery shall be included in the PPDS, if available, or publicly available documents and documented in the test reporting template. These batteries are not required to ship with the UPS.

5 TEST PROCEDURES FOR ALL PRODUCTS

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

Equation 1: Calculation of Average Power

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

Where:

- *P_{AVG} is the average power in watts.*

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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- E_{TOT} is the total energy in watt-hours.
- 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.
- P_{AVG_OUT} is the average output power in watts.
- P_{AVG_IN} is the average input power in watts.

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

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Note: EPA is proposing that thermal stabilization should only be required when testing at 100% reference test load. Because the tests are ordered from 100% of rated output power (highest thermal losses) to 0% of rated output power (lowest thermal losses), stakeholders will not realize a performance improvement by cutting this stabilization time short but could save time by doing so, which EPA believes would reduce testing burden.

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

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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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1) Test the UUT at the following reference test load conditions, in the specified order:

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a) Ac-output UPSs and high-voltage Dc-output UPSs: 100%, 75%, 50%, 25%, and 0% of the rated output power.

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b) Low-voltage Dc-output UPSs/Rectifiers: 80%, 70%, 60%, 50%, 40%, 30%, 0% of the rated output power.

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234 *Note:* For the 0% loading condition (i.e., the test load disconnected, but output inverter
235 operational for Ac-output UPS), measure only at the input to the UUT.
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237 2) The test shall be performed at each of the reference test loads by simultaneously measuring
238 the UUT's total input and output energy in Wh over a 15 minute test period. The total energy
239 accumulation rate shall be at least 1 Hz. Calculate the UUT's average input power and output
240 power for the period using Equation 1, and the UUT's efficiency using Equation 2.
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242 3) Measure and record all the applicable parameters listed in the test reporting template for each
243 Ac-output/Dc-output UPS test performed. For Ac-output UPSs, also record the input
244 dependency characteristic (AAA) in the tested modes, as specified in Section 5.3.4 of IEC
245 standard 62040-3, Ed. 2.0.
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247 D) InputPowerFactorMeasurements: Measure and report the input power factor of the UUT per Section
248 6.4.1.5 of IEC standard 62040-3, Ed. 2.0, for each mode at 100% of the reference test load.⁵
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251 6 REFERENCES

- 252
253 A) 10 CFR 430 Subpart B Appendix Y, *Uniform Test Method for Measuring the Energy*
254 *Consumption of Battery Chargers*
255 B) ATIS-0600015.04.2010, *Energy Efficiency for Telecommunication Equipment: Methodology*
256 *for Measurement and Reporting DC Power Plant – Rectifier Requirements*. January 1, 2010.
257
258 C) ATIS-0600015.2009, *Energy Efficiency for Telecommunication Equipment: Methodology*
259 *for Measurement and Reporting – General Requirements*. February 1, 2009.
260
261 D) IEC 62040-3:2011, Ed. 2.0, *Uninterruptible power systems (UPS) - Part 3: Method of specifying*
262 *the performance and test requirements*, Section J.2. March 14, 2011.
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264 E) IEC 62040-5-3: 2016, Ed. 1, *Uninterruptible power systems (UPS) - Part 5-3: DC output UPS -*
265 *Performance and test requirements*, Annex F. October 26, 2016.
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267 F) DOE Appendix Y to Subpart B of 10 CFR 430, Section 4: Testing Requirements for
268 Uninterruptible Power Supplies.
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271 **Note:** EPA is open to stakeholder feedback on other potential amendments to the UPS test method.

⁵ Neither the ATIS-0600015.2009 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.