



ENERGY STAR® Program Requirements Product Specification for Uninterruptible Power Supplies

Test Method- UPDATED DRAFT (1)

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:

- Single-phase and three-phase UPSs, for home, small and medium business, and datacenter use;
- Static and rotary UPSs; and
- Ac-output and Dc-output UPSs/Rectifiers.

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 Dc-output UPSs/Rectifiers, Alliance for Telecommunications Industry Solutions (ATIS) standards:
 - a) ATIS-0600015.2009, *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: DOE has validated the test setup and approach specified in Section J.2 of IEC standard 62040-3, Ed. 2.0. DOE and EPA became aware of the ATIS test methods through recent comments; therefore, the ATIS test methods have not been validated. DOE expects to review and validate the ATIS test procedures for Dc-output UPSs/Rectifiers over the next 12 months, which may result in technical modifications to the test method and/or specification.

37 B) Ac-input Power: The Unit Under Test (UUT) shall be connected to the first (highest) compatible
 38 voltage and frequency combination specified in Table 1.
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Table 1: Input Supply Requirements

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

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 42 1) UUTs that are not compatible with any of the combinations listed in Table 1 shall be connected to
 43 the highest nominal voltage and frequency combination. The test voltage and frequency used for
 44 the test shall be reported.
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46 C) Ac-output Power: For Ac-output UPSs, the output voltage waveform of the UUT shall have the same
 47 characteristics as the input voltage, specified in Table 1 and Section J.2 of IEC standard 62040-3, Ed.
 48 2.0.
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50 1) UUTs that have an output voltage different from the input voltage shall be tested at the highest
 51 compatible output voltage. The test voltage and frequency used for the test shall be reported.
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53 D) Dc-output Power: For Dc-output UPSs/Rectifiers, the output voltage waveform of the UUT shall be
 54 the first applicable voltage specified in Table 2, from top to bottom.
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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 %

¹ Expected voltage for a fully charged battery

57 **4 TEST CONDUCT**

58 **4.1 UPS Operating Mode Conditions**

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

- 61
- 62 ▪ The highest input dependency, and/or
 - 63 ▪ The lowest input dependency, as specified in the ENERGY STAR Eligibility Criteria for UPSs.
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65 **4.2 ENERGY STAR Guidance for Implementation of IEC 62040-3, Ed. 2.0²**

- 66 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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- 68 B) Modular UPSs tested at their minimum and maximum non-redundant configurations shall be tested
69 with redundant components (e.g., fans, controllers, etc.) for the vacant module slots functioning
70 according to the unit's as-shipped default behavior.
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- 72 C) Back-feeding the UPS shall not be used in place of a test load during testing.
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- 74 D) The UPS's firmware shall not be modified to disable energy storage charging features such as energy
75 storage self test and trickle charging.
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- 77 E) Only publicly available documents referenced in the Power and Performance Data Sheet (PPDS)
78 may be used as guidelines for implementing IEC 62040-3, Ed. 2.0. Any special instructions used shall
79 be documented in the test reporting template.
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81 **Note:** The Draft 3.0 Test Method proposed that manufacturers could provide product-specific testing
82 guidance only through the products' user manuals. Based on stakeholder comments, DOE has modified
83 the test method to allow manufacturers to provide test guidance for particular UPS models, as long as the
84 guidance is publicly available, referenced in the PPDS, and documented by the tester in the test reporting
85 template. Examples of product-specific guidance may include, but are not limited to, UPS configuration
86 details, battery removal instructions, and alarm suppression information. Making this information publicly
87 available is necessary to ensure lab-to-lab reproducibility, whether the testing is performed for
88 qualification or off-the-shelf verification.

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- 90 F) Energy Storage System:
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- 92 1) If the energy storage system is able to be disconnected by physical means or by using default
93 controls while maintaining normal operation, and the user manual does not advise against
94 disconnecting it, the UPS shall be tested with the energy storage system disconnected³.
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 - 96 2) The UPS may be adjusted to disable any alarms, indications, or default detection mechanisms
97 that may result from disconnecting the energy storage system, as long as the controls necessary
98 to do so are natively present on the UPS.
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² This guidance also applies to Dc-output UPSs/Rectifiers.

³ 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.

Note: The Draft 3.0 Test Method proposed that no changes could be made to a UPS's as-shipped configuration, if not explicitly stated in the product's user manual. This meant that the manufacturer's user manual had to specify the advisability of disconnecting the energy storage system. It also did not allow disabling of any alarms. Based on stakeholder comments, DOE has modified the test method to allow necessary actions to suppress alarms, indications, and default detection mechanisms that may result from removing the energy storage system, as long as the necessary controls are natively present on the UPS itself (i.e., no special software/tools necessary).

- 3) If unable to disconnect the energy storage system as instructed in Sections 4.2.F.1 and 4.2.F.2, the energy storage system shall store maximum energy; power to and from the energy storage system shall be minimized.
- 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 charge indicator is present.
 - ii. If there is no 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 which battery is used for the test, which shall be referenced in the PPDS and documented in the test reporting template. These units will not be required to ship with the battery chosen for testing.

5 TEST PROCEDURES FOR ALL PRODUCTS

- A) Required Calculations: Equations 1 and 2 are to be used when calculating the unit's average power and efficiency:

Equation 1: Calculation of Average Power for Ac-Output UPSs

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

Where:

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

Equation 2: Calculation of Efficiency for Ac-Output UPSs

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

Where:

- 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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Note: Based on stakeholder comments, DOE has clarified how to calculate average power and UPS efficiency.

- B) **Steady-state:** Allow the UUT to stabilize for 125% of the manufacturer-specified rise time, as instructed in IEC 62040-3, Ed. 2.0. During the final 20 minutes of the stabilization period, at each loading point, perform the following steady-state check:
- 1) Measure the unit's accumulated energy in watt-hours (Wh) for at least 5 minutes using a power meter.
 - 2) Calculate the unit's average power in watts (W) over the 5 minute period using Equation 1.
 - 3) Calculate the unit's efficiency over the 5 minute period using Equation 2.
 - 4) Wait a minimum of 10 minutes.
 - 5) Repeat steps 1 to 3 for another 5 minute measurement.
 - 6) Compare the two efficiency calculations attained in step 3 and step 5.
 - 7) The test unit is at steady-state if the absolute value of the difference between the two efficiency calculations is less than one percent of the average of the two readings.
 - 8) If the absolute value of the difference between the efficiency calculations is greater than or equal to one percent of their average, repeat steps 4 to 6 until the unit is considered to be at steady-state. Record the appropriate values in the test reporting template.

Note: Based on stakeholder recommendations in the Draft 3.0 Test Method webinar, DOE has modified the test method so that the steady-state check is performed in the final 20 minutes of the stabilization period. DOE expects this to reduce test burden by minimizing additional test time.

In the Draft 3.0 Test Method, two average power calculations were used to determine UPS stability. Stakeholders commented that this method is burdensome and may not apply to larger UPSs. In response, DOE has modified the Final Draft Test Method to use efficiency, rather than average power, to check for stability. In validation testing we observed that the efficiency will remain constant for a stable UPS, although the average power may drift. DOE believes that by using efficiency rather than average power to determine stability, the requirements for attaining steady-state will be less stringent, regardless of UPS size. DOE and EPA welcome comment on this change.

- 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.
- 1) Test the UUT at the following reference test load conditions:
 - a) Ac-output UPS: 100%, 75%, 50%, 25%, and 0% of the reference test load.
 - b) Dc-output UPS: 80%, 70%, 60%, 50%, 40%, 30%, 0% of the reference test load.
Note: For the 0% loading condition (i.e., the test load disconnected, but output inverter operational for Ac-output UPS), measure only at the input to the UUT.
 - 2) The test shall be performed by accumulating the total energy in Wh over a 15 minute test period, then determining the average power for the period using Equation 1.

Note: Total energy accumulation rate shall be at least 1 Hz.

194 **Note:** Stakeholders expressed concern that the sampling method proposed in Draft 3.0 of the Test
195 Method differs from the sampling method used in IEC 62040-3, Ed. 2.0. DOE would like to clarify that
196 accumulating energy over a 15 minute measurement period will suppress outlier data and preclude the
197 need for data acquisition programs. By accumulating total energy data over a 15 minute period, only one
198 total energy reading needs to be recorded. This measurement is obtained as a direct reading from the
199 power meter display, the same way measurements are obtained in IEC 62040-3, Ed. 2.0. DOE believes
200 this approach increases measurement accuracy, while minimizing test burden.

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202 Stakeholders also commented that the sampling method proposed in the Draft 3.0 Test Method is not well
203 defined. DOE has clarified that the rate at which the power meter accumulates energy shall be at least
204 1 Hz, based on power meter capabilities observed in the market. DOE and EPA welcome comment on
205 this change.

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207 3) Modular UPSs with output power that varies depending on the number of converters installed
208 shall be tested twice, at both their minimum and maximum non-redundant (i.e., N+0)
209 configurations.

210 a) For Dc-output UPSs/Rectifiers, this test method shall take precedence over the
211 requirements specified in Section 5.10 of the ATIS -0600015.2009 standard⁴.

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214 4) Measure and record all the applicable parameters listed in the test reporting template for each
215 Ac-output/Dc-output UPS test performed, including the Ac-output UPS performance
216 characteristics in the tested modes, as specified in Section 5.3.4 of IEC standard 62040-3, Ed.
217 2.0.

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219 D) Power Factor Measurements: Measure the power factor of the UUT per Section 6.4.1.5 of IEC
220 standard 62040-3, Ed. 2.0, for each mode.⁵

221 222 **6 REFERENCES**

223 A) ATIS-0600015.04.2010, *Energy Efficiency for Telecommunication Equipment: Methodology for*
224 *Measurement and Reporting DC Power Plant – Rectifier Requirements*. January 1, 2010.

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226 B) ATIS-0600015.2009, *Energy Efficiency for Telecommunication Equipment: Methodology for*
227 *Measurement and Reporting – General Requirements*. February 1, 2009.

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229 C) IEC 62040-3:2011, Ed. 2.0, *Uninterruptible power systems (UPS) - Part 3: Method of specifying the*
230 *performance and test requirements*, Section J.2. March 14, 2011.

⁴ The ATIS-0600015.2009 specifies that modular dc-Output UPSs/Rectifiers may be tested on a per-module basis.

⁵ Neither the ATIS-0600015.2009 nor the ATIS-0600015.04.2010 standard specifies requirements for testing power factor; therefore, the provisions contained in section 6.4.1.5 of IEC standard 62040-3 will be used for testing the power factor of dc-output UPSs/Rectifiers.