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

Note: The requirement in Section 6.2 of ATIS-0600015.04.2010 which states the Unit Under Test (UUT) shall be evaluated with “a power source with a rating of at least 2X the maximum input power rating of the rectifier” is optional for ENERGY STAR testing.
B) **Ac-input Power:** The UUT shall be connected to the first (highest) rated voltage and rated frequency combination specified in Table 1. If two frequencies are provided in a given row, the manufacturer may specify which frequency shall be used for testing.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>600(\Delta) V ac</td>
<td>60 Hz</td>
</tr>
<tr>
<td>600Y/346 V ac</td>
<td>60 Hz</td>
</tr>
<tr>
<td>480(\Delta) V ac</td>
<td>60 Hz</td>
</tr>
<tr>
<td>480Y/277 V ac</td>
<td>60 Hz</td>
</tr>
<tr>
<td>415(\Delta) V ac</td>
<td>60 Hz</td>
</tr>
<tr>
<td>415Y/240 V ac</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>400(\Delta) V ac</td>
<td>50 Hz</td>
</tr>
<tr>
<td>400Y/230 V ac</td>
<td>50 Hz</td>
</tr>
<tr>
<td>380Y/220 V ac</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>230 V ac</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>208(\Delta) V ac</td>
<td>60 Hz</td>
</tr>
<tr>
<td>208Y/120 V ac</td>
<td>60 Hz</td>
</tr>
<tr>
<td>200 V ac</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>120 V ac</td>
<td>60 Hz</td>
</tr>
<tr>
<td>115 V ac</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>100 V ac</td>
<td>50 or 60 Hz</td>
</tr>
</tbody>
</table>

**Note:** Based on stakeholder comments, the following modifications have been made to Table 1:
- Added 380Y/220 V ac 50 Hz, as it is common in several countries around the world
- Added 200 V ac 60 Hz to accommodate the nominal voltage of Japan
- Added 120 V ac 60 Hz to accommodate the nominal voltage of North America

To avoid issues that may result from the inclusion of both the 50 and 60 Hz frequencies for these two input supplies, language has been added to Section 3.B, above, to allow the manufacturer to specify the frequency used for testing.

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

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

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

D) **Dc-output Power:** For Dc-output UPSs/Rectifiers, the output voltage of the UUT shall be the first applicable voltage specified in Table 2, from top to bottom. The voltage used for the test shall be reported.
Table 2: Dc-output Power Requirements and Precedence

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Voltage for Test</th>
<th>Voltage Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>380 V dc</td>
<td>418 V dc</td>
<td>+/- 1 %</td>
</tr>
<tr>
<td>48 V dc</td>
<td>53 V dc</td>
<td>+/- 1 %</td>
</tr>
<tr>
<td>60 V dc</td>
<td>66 V dc</td>
<td>+/- 1 %</td>
</tr>
<tr>
<td>24 V dc</td>
<td>26 V dc</td>
<td>+/- 1 %</td>
</tr>
<tr>
<td>575 V dc</td>
<td>595 V dc</td>
<td>+/- 1 %</td>
</tr>
</tbody>
</table>

4 TEST CONDUCT

Note: “Section 4: Test Conduct” and “Section 5: Test Procedures for All Products” apply to both Ac-output and Dc-output UPSs. The standards referenced in Section 3.A.2 shall be used only for setup and instrumentation guidance in the testing of Dc-output UPSs.

4.1 UPS Operating Mode Conditions

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:

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

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

Note: DOE has added clarification that, if applicable, the test unit shall be tested in the highest efficiency sub-mode of each tested normal mode.

4.2 ENERGY STAR Guidance for Implementation of IEC 62040-3, Ed. 2.0

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

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

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

1 Expected voltage for a fully charged battery
2 This guidance also applies to Dc-output UPSs/Rectifiers.
3 The ATIS-0600015.2009 specifies that modular Dc-Output UPSs/Rectifiers may be tested on a per-module basis.
C) Modular UPSs tested at their minimum and maximum non-redundant configurations shall be tested with redundant components (e.g., fans, controllers, etc.) of the vacant module slots functioning according to the unit's as-shipped default behavior.

D) Back-feeding the UPS may be used in place of a test load during testing of UPS systems larger than 100 kW output.

E) The UPS's firmware shall not be modified to disable energy storage charging features such as energy storage self test and trickle charging.

F) Only publicly available documents referenced in the Power and Performance Data Sheet (PPDS) may be used as guidelines for implementing IEC 62040-3, Ed. 2.0. Any special instructions used shall be documented in the test reporting template.

G) **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 does not advise against disconnecting it, the UPS shall be tested with the energy storage system disconnected.

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.

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**Note:** Based on stakeholder recommendations, DOE has modified this requirement to allow the use of end user software to disable any resulting alarms. The intent is to allow for repeatable off-the-shelf testing by any tester.

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 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.

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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.
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.
- \( E_{TOT} \) is the total energy in watt-hours.
- \( t \) is the length of the measurement in hours.

**Equation 2: Calculation of Efficiency**

\[ Eff = \frac{P_{AVG,OUT}}{P_{AVG,IN}} \]

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.

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) Simultaneously measure the unit’s accumulated input and output 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.

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 rated output power.
   b) Dc-output UPS: 80%, 70%, 60%, 50%, 40%, 30%, 0% of the rated output power.

   **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 at each of the reference test loads by simultaneously accumulating the total input and output 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.

3) Measure and record all the applicable parameters listed in the test reporting template for each Ac-output/Dc-output UPS test performed, including the Ac-output UPS input dependency characteristic (AAA) in the tested modes, as specified in Section 5.3.4 of IEC standard 62040-3, Ed. 2.0.

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

6 REFERENCES


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.