



ENERGY STAR® Program Requirements Product Specification for Uninterruptible Power Supplies

Final DRAFT Test Method

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).

Note: This is a Draft ENERGY STAR Test Method for Uninterruptible Power Supplies (UPSs) which is being proposed for use in dataset assembly as part of the ENERGY STAR specification development process. EPA has extended the dataset assembly period through March 18, 2011.

This draft may be revised prior to implementation as the final ENERGY STAR Test Method for determining product compliance with the future specification. For example, the definitions, which are presented here for ease of reference, will be moved into the eligibility criteria and further refined during the specification development process.

When reviewing this draft, EPA invites stakeholders to think beyond the immediate needs of the data generating process, and consider the potential impact of the test procedure on the later specification development process.

2 APPLICABILITY

The following test method is applicable to all products eligible for qualification under the 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.

Note: The U.S. Department of Energy (DOE) has recently proposed a battery charger efficiency test procedure that may also apply to consumer-scale UPSs. However, the DOE test procedure only addresses the efficiency of the UPS with the load disconnected. EPA is therefore proposing this test procedure as a more complete assessment of UPS efficiency during typical use with an information technology load.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Eligibility Criteria for UPSs and in the International Electrical Commission (IEC) standard IEC 62040-3/FDIS¹.

For the purpose of this test method, the following definitions apply:

¹ International Electrotechnical Commission (IEC). IEC standard 62040-3 Final Draft International Standard (FDIS). "Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements." Ed. 2.0

30 **Note:** The definitions listed below will be moved to the ENERGY STAR specification for UPSs, but are
31 presented here for stakeholder review and to inform testing prior to the development of the specification.

32 Unless otherwise identified through note boxes, the definitions below have been taken from IEC standard
33 IEC 62040-3/FDIS. All references will be updated once the final IEC 62040-3 standard is published.

34 A) Product Types:

35 1) Uninterruptible Power Supply (UPS): Combination of convertors, switches, and energy storage
36 devices (such as batteries) constituting a power system for maintaining continuity of load power in
37 case of input power failure.²

38 i) Energy storage mechanism:

39 (1) Static UPS: UPS where solid-state power electronic components provide the output
40 voltage.

41 (2) Rotary UPS: UPS where one or more electrical rotating machines provide the output
42 voltage.

43 2) Modular UPS: A UPS in which multiple converters share a common frame, input and output
44 busses, and/or other UPS components. The converters are connected in parallel and can be
45 added to or removed from the UPS to change its rated output power.

46 **Note:** IEC standard 62040-3/FDIS does not include a definition of a modular UPS, so the above definition
47 was created by ENERGY STAR based on general discussions with stakeholders to facilitate testing of
48 modular UPSs on par with non-modular UPSs.

49 B) Redundancy: Addition of UPS Units in a parallel UPS to enhance the continuity of load power, and
50 classified as follows.

51 1) N+0: UPS that cannot tolerate any failures while maintaining Normal Mode operation. No
52 redundancy.

53 2) N + 1: Parallel UPS that can tolerate the failure of one UPS unit or one group of UPS units
54 while maintaining Normal Mode operation.

55 3) 2N: Parallel UPS that can tolerate the failure of one half of its UPS units while maintaining
56 Normal Mode operation.

57 **Note:** The definition of redundancy is based on that of “Redundant System” in IEC standard 62040-
58 3/FDIS. The remainder of the definitions are intended to help distinguish between different levels of
59 redundancy, and therefore performance, when comparing efficiency results. EPA is aware that non-
60 redundant UPSs can be combined at the time of installation in a data center application to provide
61 redundant operation, and will be examining all the ramifications of redundancy during the ENERGYSTAR
62 specification development process.

63 C) UPS Operational Modes:

64 1) Normal Mode: Stable mode of operation that the UPS attains under the following conditions:

65 i) AC input supply is within required tolerances and supplies the UPS (per Table 1).

66 ii) The energy storage system remains charged or is under recharge.

67 iii) The load is within the specified rating of the UPS.

68 iv) The bypass is available and within specified tolerances (if applicable).

² Input power failure occurs when voltage and frequency are outside rated steady-state and transient tolerance bands or when distortion or interruptions are outside the limits specified for the UPS.

- 69 2) Stored Energy Mode: Stable mode of operation that the UPS attains under the following
70 conditions:
- 71 i) AC input power is disconnected or is out of required tolerance (per Table 1).
72 ii) All power is derived from the energy storage system.
73 iii) The load is within the specified rating of the UPS.
- 74 3) Bypass Mode: Mode of operation that the UPS attains when operating the load supplied via the
75 bypass only.

76 D) UPS Topologies

- 77 1. Passive Standby: UPS operation where the normal mode of operation consists of supplying the
78 load from the primary power source, except when the latter is outside stated limits in which case
79 the load is supplied from the UPS inverter operating in stored energy mode.³
- 80 2. Line Interactive: UPS operation where, in normal mode of operation, the load is supplied with
81 conditioned AC input power at the input supply frequency and where, in stored energy mode of
82 operation, the load is supplied from the output of an inverter.
- 83 Double Conversion: UPS operation, where continuity of load power is maintained by a UPS
84 inverter, with energy supplied from the DC link in normal mode of operation or from the energy
85 storage system in stored energy mode of operation.⁴

86 **Note:** The above definitions are taken from IEC standard 62040-3/FDIS, and are intended to be used to
87 classify UPSs during data analysis. Topologies not listed above (e.g., Delta Conversion) can be
88 considered a subtype of one of the included definitions, or specified separately, along with a brief
89 explanation, in the data collection sheet. These classifications are purely informational and it is EPA's
90 preference to develop a specification structure that promotes energy efficiency benefits independent of
91 topology. This strategy is consistent with the ENERGY STAR program's overall technology-agnostic
92 approach.

93 E) UPS Power:

- 94 1) Alternating Current (AC): A continuous flow of electric charge that periodically reverses direction.
- 95 i) Single-phase: Distribution of AC electric power using a system with two conductors and one
96 voltage.
- 97 ii) Three-phase: Distribution of AC electric power using a system with three or four conductors
98 in which three voltage waveforms of equal amplitude and frequency are offset in phase by
99 120 degrees.
- 100 2) Direct Current (DC): A continuous flow of electric charge that is unidirectional.

101 **Note:** The above definitions are derived from the framework document published in February 2010.

102 F) Other Terms:

- 103 1) Bypass: Power path alternative to the AC converter.
- 104 a) Maintenance bypass (path): Alternative power path provided to maintain continuity of
105 load power during maintenance activities.
- 106 b) Static bypass (electronic bypass): power path (primary or stand-by) alternative to the
107 indirect AC converter where control is via an electronic power switch, for example
108 transistors, thyristors, triacs or other semiconductor device or devices

³ The primary power may be regulated by additional devices, e.g. ferro-resonant or static regulators.

⁴ The output voltage and frequency are independent of input voltage and frequency conditions.

- 109 G) DC Link: Direct current power interconnection between the rectifier or rectifier/charger and the
 110 inverter functional unit.⁵
- 111 H) Reference Test Load: A load or a condition in which the output of the UPS delivers the active power
 112 (W) for which the UPS is rated.⁶
- 113 I) Unit Under Test (UUT): The UPS undergoing the test, configured as though for shipment to the
 114 customer, and including any accessories (e.g., filters or transformers) necessary to meet the test
 115 setup as specified in section 4 of this test method.

116 **Note:** The intent of the UUT definition is to test the UPS in an 'As Shipped' condition.

117 **4 TEST SETUP**

- 118 A) Test Setup and Instrumentation: Test setup and instrumentation for all portions of this procedure shall
 119 be in accordance with the requirements in section J.2 of IEC standard 62040-3/FDIS, unless
 120 otherwise specified in this section.
- 121 B) AC Input Power: The UUT shall be connected to the first (highest) compatible voltage and frequency
 122 combination specified in Table 1.
- 123 1) UUTs that are not compatible with any of the combinations listed in Table1 shall be connected to
 124 their most typically used nominal voltage and frequency combination. The test voltage and
 125 frequency used for the test shall be reported.

126 **Table 1: Input Power Requirements**

Voltage*	Frequency
600Δ VAC	60 Hz
600Y/346 VAC	60 Hz
480Δ VAC	60 Hz
480Y/277 VAC	60Hz
415Δ VAC	60 Hz
415Y/240 VAC	60 Hz
400Δ VAC	50 Hz
400Y/230 VAC	50 Hz
208Δ	60 Hz
208Y/120 VAC	60 Hz
200 VAC	50 Hz
100 VAC	50 or 60 Hz

⁵ The voltage of the energy storage system may differ from that of the DC link. The DC link may include converters.

⁶ This definition permits the UPS output to be backfed into the input AC supply when in test-mode and subject to local regulations.

Voltage*	Frequency
----------	-----------

* Note: Δ refers to the line-to-line voltage between delta-connected three-phase windings, while Y refers to the line-to-line voltage between Y-connected three-phase windings, where the line-to-neutral voltage (also used in single-phase testing) is $1/\sqrt{3}$ of the line-to-line voltage.

127

128 C) AC Output Power: For AC-output UPSs, the output voltage waveform of the UUT shall have the same
 129 characteristics as the input voltage, specified in Table 1 and section J.2 of IEC standard 62040-
 130 3/FDIS.

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

133 D) DC Output Power: For DC-output UPSs, the output voltage waveform of the UUT shall be the first
 134 voltage and frequency combination specified in Table 2.

135

Table 2: DC Output Power Requirements

Voltage*	Voltage Tolerance
380 VDC	+/- 1 %
48 VDC	+/- 1 %
60 VDC	+/- 1 %
24 VDC	+/- 1 %

136 **5 TEST CONDUCT**

137 A) If the UUT can operate in two or more distinct normal modes, conduct all parts of the test and report
 138 all parameters listed in Appendix A in:

- 139 1) The highest efficiency/lowest protection mode,
- 140 2) The lowest efficiency/highest protection mode, and
- 141 3) (Optional) Any additional modes, if desired.

142 B) Efficiency Measurements: Input and output power measurements for efficiency calculations shall be
 143 performed on the UUT according to section J.3 of IEC standard 62040-3/FDIS, with the following
 144 exceptions.

- 145 1) Test the UUT at 100%, 75%, 50%, 25%, and 0% of the reference test load.
- 146 2) (Optional) Test the following loading points, if desired: 10%, 20%, 30%, and 40% of the reference
 147 test load.
- 148 3) For the 0% loading condition (i.e., test load disconnected, but output inverter operational),
 149 measure only the input power to the UUT.
- 150 4) Modular UPSs with output power that varies depending on the number of converters installed,
 151 shall be tested twice, at both their minimum and maximum non-redundant (ie: N+0)
 152 configurations.

- 153 5) Measure and record all the applicable parameters listed in Appendix A of this test method for
154 each test performed, including the performance characteristics in the tested modes, as specified
155 in section 5.3.4 of IEC standard 62040-3/FDIS.
- 156 i) If all three parts of the output performance characteristics (AAA-BB-CCC) are not available or
157 applicable, report only the characteristics applicable for the UUT.
- 158 C) Power Factor Measurements: Measure the power factor of the UUT per section 6.4.1.5 of IEC
159 standard 62040-3/FDIS, for each mode.