ENERGY STAR® Program Requirements Product Specification for Uninterruptible Power Supplies

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 for the initial data collection as part of the ENERGY STAR specification development process. The data collection process will follow the development of this test procedure and is expected to run from December 2010 through February 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.

The U.S. Environmental Protection Agency (EPA) is inviting comment on this draft, to ensure that all data submitted is consistent and relevant. In particular, EPA seeks feedback on any gaps when addressing a full suite of UPS products. In addition,

EPA invites stakeholders to think beyond the immediate needs of the data call, 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 office, 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 62040-3[1].

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

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

Unless otherwise identified through note boxes, the definitions below have been taken from IEC standard 62040-3. EPA invites comment on their applicability to this test method.

A) Product Types:

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

i) Energy storage mechanism:

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

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

Note: The two definitions above are based on the definition for Rotary UPS in IEC standard 88528-11.[3] EPA intends for this test procedure to apply to both types of UPSs.

ii) UPS Modularity:

(1) UPS Unit: Complete UPS consisting of at least one of each of the following functional units: UPS inverter, UPS rectifier and battery or other energy storage means.[4]

(2) Single UPS: UPS comprising only one UPS unit.

(3) Parallel UPS: UPS comprising two or more UPS units operating in parallel.

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

1) N: Parallel UPS that cannot tolerate any failures while maintaining Normal Mode operation. No redundancy.

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

2 Continuity of load power occurs when voltage and frequency are within rated steady-state and transient tolerance bands and when distortion and interruptions are within the limits specified for the load. 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.

3 IEC standard 88528-11. "Reciprocating internal combustion engine driven alternating current generating sets—Part 11: Rotary uninterruptible power systems—Performance requirements and test methods." Ed. 1.0.

4 A UPS unit may operate with other UPS units to form a parallel or redundant UPS

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

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

Note: The definition of redundancy is based on that of "Redundant System" in IEC standard 62040-3. The remainder of the definitions are intended to help distinguish between different levels of redundancy, and therefore reliability, when comparing efficiency results. EPA is aware that non-redundant UPSs can be combined at the time of installation in a data center application to provide redundant operation, and will be examining all the ramifications of redundancy during the ENERGYSTAR specfication development process.

C) UPS Operational Modes:

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

i) AC input supply is within required tolerances and supplies the UPS (per Table 1 or Table 2).

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

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

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

Note: The above definition of Normal Mode has been taken from IEC standard 62040-3, and can be interpreted as also including "Eco" and "Energy Saver" modes. EPA has received numerous comments on these modes, explaining their utility as well as their limitations, and will continue to evaluate how to treat them in the ENERGY STAR eligibility criteria for UPSs.

Energy Saver modes are included as Normal Modes in this test procedure to permit their testing alongside more traditional Normal Modes, and allow ENERGY STAR to make the best decision regarding their treatment during the specification development process. To that end, EPA welcomes comment on the information that should be collected under this test procedure that would allow for an assessment of any efficiency and reliability tradeoffs.

2) Stored Energy Mode: Stable mode of operation that the UPS attains under the following conditions:

i) AC input power is disconnected or is out of required tolerance (per Table 1 or Table 2).

ii) All power is derived from the energy storage system.

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

3) Hibernate Mode: Stable mode of operation intended only to maintain the charge on the battery, where the UPS draws power but the inverter and other load-protection circuitry are not operational. Entry into this mode can be manual or automatic. This Mode is different than Bypass State, which is typically only used to perform maintenance, in that this mode can persist indefinitely.

Note: A definition for Hibernate Mode was included in response to stakeholder comments and is intended to be reflective of the situation where a UPS has been commissioned, is maintaining the charge on the batteries, but is not supplying a load. See also the discussion of 0% load testing in section 4, below.

4) Bypass State: State the UPS attains when operating the load supplied via the bypass only.

5) Charging State: State the UPS attains when the AC input supply is within required tolerances and supplies the UPS and the energy storage is under recharge. The load need not be connected.

Note: The definition for Charging State was provided by stakeholders through comments, and EPA is including it in the list of definitions for completeness. Due to the infrequency of the charging mode in most applications, EPA proposes not to test UPSs in this mode.

D) UPS Topologies

1) Passive Standby: Any UPS operation where, in normal mode of operation, the load is primarily supplied by primary power and is subject to input voltage and frequency variations within stated limits. When the AC input supply is out of UPS design load tolerances, the UPS inverter is activated from the battery and maintains continuity of load power in stored energy mode of operation.

2) Line Interactive: Any UPS operation where, in normal mode of operation, the load is supplied with conditioned AC input power at the input supply frequency and where, in stored energy mode of operation, the load is supplied from the output of an inverter.

3) Double Conversion: Any UPS operation, where continuity of load power is maintained by a UPS inverter, with energy from the DC link in normal or from the energy storage system in stored energy mode of operation. The output voltage and frequency are independent of input voltage and frequency conditions.

Note: The above definitions are taken from IEC standard 62040-3, and are intended to be used to classify UPSs during data analysis. Topologies not listed above (e.g., Delta Conversion) can be considered a subtype of one of the included definitions, or specified separately in the laboratory report. These classifications are purely informational and upon development of requirements, it is EPA's preference to develop a specification structure that promotes energy efficiency benefits independent of topology. This strategy is consistent with the ENERGY STAR program's technology-agnostic approach.

E) UPS Power:

1) Alternating Current (AC): A continuous flow of electric charge that periodically reverses direction.

i) Single-phase: Distribution of AC electric power using a system with two conductors and one voltage.

ii) Three-phase: Distribution of AC electric power using a system with three or four conductors in which three voltage waveforms of equal amplitude and frequency are offset by 120 degrees.

2) Direct Current (DC): A continuous flow of electric charge that is unidirectional.

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

F) Unit Under Test (UUT): The UPS undergoing the test, configured as though for shipment to the customer, and including any accessories (e.g., filters or transformers) necessary to meet the test setup as specified in section 4 of this test method.

Note: The intent of the UUT definition is to establish a common set of output and input characteristics to enable meaningful comparisons between UPSs tested per this test procedure. EPA is currently evaluating the treatment of input and output accessories in the European Union Code of Conduct for UPSs,[5] which specifies performance at a number of voltages and provides allowances for transformers and filters. EPA will address this issue in detail during the specification development process and welcomes comments on this approach.

5 European Commission. "Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems (UPS). Version 1.0a., January 22, 2008.

G) Reference Test Load: A load or a condition in which the output of the UPS delivers at least the active power (W) for which the UPS is rated.[6]

4 TEST SETUP

A) Test Setup and Instrumentation: Test setup and instrumentation for all portions of this procedure shall be in accordance with the requirements in section J.2 of IEC standard 62040-3, unless otherwise specified in this section.

B) AC Input Power: The UUT shall be connected to a voltage source appropriate for the intended market, as specified in Table 1 for single-phase products and Table 2 for three-phase products.

Note: EPA invites comment on the best way to segment consumer/small office and datacenter UPSs based on clearly observable attributes. This draft test procedure uses the number of phases; however, stakeholders have also suggested output power (e.g., 1.5 kW). EPA also invites comment on the test conditions for the two categories of UPSs specified in Table 1 and Table 2.

Table 1: Input Power Requirements for Single-Phase Products

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	115 VAC	+/- 1.0 %	2.0 %	60 Hz	+/- 1.0 %
Europe, Australia, New Zealand	230 VAC	+/- 1.0 %	2.0 %	50 Hz	+/- 1.0 %
Japan	100 VAC	+/- 1.0 %	2.0 %	50Hz/ 60 Hz	+/- 1.0 %

Table 2: Input Power Requirements for Three-Phase Products

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	277/480 VAC	+/- 4.0 %	5.0 %	60 Hz	+/- 1.0 %
Europe, Australia, New Zealand, Japan	230/400 VAC	+/- 4.0 %	5.0 %	50Hz	+/- 1.0 %

C) AC Output Power: AC-output UPSs shall be tested as specified below:

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

1) Single Phase: The output voltage waveform of the UUT shall have the same characteristics as the input voltage, specified in Table 1.

2) Three-Phase: The output voltage waveform of the UUT shall have:

i) The same frequency characteristics as the input voltage, specified in Table 2; and

ii) The same voltage characteristics as the input voltage for Europe, Australia, and New Zealand (i.e., 230/400 VAC), specified in Table 2.

Note: Industry stakeholders hav e provided EPA with a list of typical UPS operating voltage, and EPA recognizes that that the majority of UPS systems in North America have a 346/600 V or 277/480 V output, and that this output is transformed down to 208 VAC to power the end-use loads (e.g., servers). However, the ENERGY STAR program for servers specifies testing at 230 VAC, and operating at this higher voltage results in lower losses in the wiring as well as the power supply; therefore, the higher voltage is proposed for UPS testing to promote more efficient operation. Nonetheless, EPA welcomes suggestions on these test conditions as well as the addition of input or output accessories (see paragraph E), below), for units that cannot meet the specified test conditions.

EPA is further considering specifying that output testing be performed at 240/415 VAC, to ensure that ENERGY STAR UPSs can operate at this higher voltage and permit datacenter operators to reap any further incremental gains in efficiency.

Finally, EPA is also interested in fully transformerless UPS operation at 400 or 415 VAC and welcomes comment on the test conditions that could best evaluate its energy saving benefits.

D) DC Output Power: DC-output UPSs shall be tested at an output voltage of 380 V +/- 1.0 %.

Note: EPA wishes to include DC UPSs in the specification development process due to their potential to facilitate efficiency improvements beyond the UPS, by eliminating entirely the losses in the UPS output inverter and the end-use power supply rectifier. Because of their low market penetration at present, not much is known about their operation, and EPA welcomes comments on the appropriate test conditions for these products.

E) Input or Output Devices: Any input or output transformers or filters necessary to meet the input or output power specifications, provided in paragraphs B) and C), above, shall be considered a part of the UUT, and described in the test report.

5 TEST CONDUCT

F) 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, with the following exceptions.

1) Test the UUT at 100%, 75%, 50%, 40%, 30%, 20%, 10%, and 0% of the reference test load.

Note: IEC standard 62040-3 requires testing at only four loading points: 100%, 75%, 50%, and 25% of the reference test load. Although some stakeholders suggested additional loading points to provide more resolution into UPS performance, EPA recognizes the burden imposed by each additional testing condition and proposes additional points at lower load as a compromise. EPA welcomes comment on this proposal.

2) For the 0% loading condition, measure only the input power to the UUT.

i) Manually place the UPS into a Hibernate Mode, if available.

3) For battery-powered UPSs, and following the measurement of UUT input power at 0% load, test whether the battery would continue to receive a float charge if it were connected.

Note: According to stakeholder comments on the specification framework, energy losses due to underutilized UPSs may be improved through enabling battery charging/ maintenance with the output inverter turned off, in a "standby" or "hibernate" mode. EPA welcomes comment on the best way to test UPS performance in this mode, such as through monitoring the status display of the UPS, momentarily connecting the batteries to measure charging current, or momentarily connecting a test load intended to mimic the batteries.

4) Parallel UPSs with output power that varies depending on the number of UPS units installed, shall be tested twice, at both their minimum and maximum configurations.

5) Repeat the test in each Normal Mode, including any labeled as Energy Saver Modes.

6) Measure and record all the applicable parameters listed in Appendix A of this test method for each test performed, including the performance characteristics in the tested Normal Mode, as specified in section 5.3.4 of IEC standard 62040-3.

G) Power Factor Measurements: Measure the power factor of the UUT per section 6.4.1.5 of IEC standard 62040-3, for each Normal Mode, including any labeled as Energy Saver Modes.

H) Overload Measurements: With the UUT configured per section 4 of this test method, load the UUT according to the following conditions, and measure the duration (in minutes) that the UUT continues to operate within Normal Mode without damage or signs of over-heating.

1) 125% of the reference test load;

2) 150% of the reference test load;

3) 200% of the reference test load; and

4) Any other conditions desired.

5) Return to normal mode after each test, and wait for the UUT to recover, performing any necessary resets.

6) Repeat the test in each Normal Mode, including any labeled as Energy Saver Modes.

Note: The above requirement is based on that in section 6.4.2.10.1 of IEC standard 62040-3, which specifies the testing of a manufacturer's overload claims. According to comments on the specification framework received from stakeholders, overload handling allows a facility manager to use an EPS closer to 100% load where the efficiency is highest. EPA therefore intends to require overload reporting; however, EPA intends to do so in a safe manner and welcomes comment on the best method of providing standardized information regarding overload capability to end-users.