ENERGY STAR® Program Requirements Product Specification for Computers

Final Draft Test Method Rev. September-2019

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Specification for Computers.

2 APPLICABILITY

ENERGY STAR test requirements are dependent upon the feature set of the product under evaluation. The following guidelines shall be used to determine the applicability of each section of this document:

- The procedure in Section 6 shall be conducted on all eligible products that are covered under the scope as defined in Section 2 of the ENERGY STAR Eligibility Criteria for Computers.
- The procedure in Section 7 shall be conducted only on eligible Workstation Computer products.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Specification for Computers.

4 TEST SETUP

4.1 Test Setup and Instrumentation

Test setup and instrumentation for all portions of this procedure shall be in accordance with the requirements of International Electrotechnical Commission (IEC) standard, IEC 62301, "Household Electrical Appliances – Measurement of Standby Power" Edition 2.0, 2011-01, Section 4, "General Conditions for Measurements", unless otherwise noted in this document. In the event of conflicting requirements, the ENERGY STAR test method shall take precedence.

A) Input Power: Products intended to be powered from alternating current (ac) mains shall be connected to a voltage source appropriate for the intended market, as specified in Table 1 and Table 2.

Table 1: Input Power Requirements for Products with Nameplate Rated Power Less Than or Equal to 1500 watts (W)

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	115 volts (V) ac	+/- 1.0 %	2.0 %	60 hertz (Hz)	+/- 1.0 %
Europe, Australia, New Zealand	230 V ac	+/- 1.0 %	2.0 %	50 Hz	+/- 1.0 %
Japan	100 V ac	+/- 1.0 %	2.0 %	50 Hz or 60 Hz	+/- 1.0 %

Table 2: Input Power Requirements for Products with Nameplate Rated Power Greater Than 1500 W

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	115 V ac	+/- 4.0 %	5.0 %	60 Hz	+/- 1.0 %
Europe, Australia, New Zealand	230 V ac	+/- 4.0 %	5.0 %	50 Hz	+/- 1.0 %
Japan	100 V ac	+/- 4.0 %	5.0 %	50 Hz or 60 Hz	+/- 1.0 %

B) Ambient Temperature: Ambient temperature shall remain between 18 °C and 28 °C, inclusive, for the duration of the test.

C) Relative Humidity: Relative humidity shall remain between 10% and 80%, inclusive, for the duration of the test.

D) Light Measuring Device (LMD): All LMDs shall meet the following specifications:

1) Accuracy: ± 2% (± 2 digits) of the digitally displayed value; and

2) Acceptance Angle: 3 degrees or less.

The overall tolerance of LMDs is found by taking the absolute sum of 2%of the targeted screen luminance and a 2 digit tolerance of the displayed value's least significant digit. For example, if the screen luminance value is 90 candela per meter squared (cd/m^2) and the LMD's least significant digit is a tenth of one cd/m^2, 2% of 90 cd/m^2 would be 1.8 cd/m^2 and a 2 digit tolerance of the least significant digit would be 0.2 cd/m^2. Thus, the displayed value would need to be 90 ± 2 cd/m^2 (1.8 cd/m^2 + 0.2 cd/m^2).

Note: The term "nit" is sometimes used instead of the official SI unit cd/m^2. One nit is equivalent to one cd/m^2.

E) Power Meter: Power meters shall possess the following attributes:

1) Crest Factor:

a) An available current crest factor of 3 or more at its rated range value; and

b) A bound on the current range of 10 milliamperes (mA) or less.

2) Minimum Frequency Response: 3.0 kilo-hertz (kHz)

3) Minimum Resolution:

a) 0.01 W for measurement values less than 10 W;

b) 0.1 W for measurement values from 10 W to 100 W; and

c) 1.0 W for measurement values greater than 100 W.

4) Measurement Accuracy: Measurement uncertainty as introduced by the instrument that measures the input power to the unit under test (UUT), including any external shunts.

a) Power measurements with a value greater than or equal to 0.5 W shall be made with an uncertainty of less than or equal to 2% at the 95% confidence level.

b) Power measurements with a value less than 0.5 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level.

5 TEST CONDUCT

5.1 Guidance for Implementation of IEC 62623

The Test Conduct shall be carried out according to the requirements in IEC 62623, "Desktop and Notebook Computers – Measurement of Energy Consumption" Edition 1.0, 2012-10 (IEC 62623 Ed. 1.0, 2012-10) reference with the following guidance.

A) Thin Clients and Workstations shall be configured in a manner identical to Desktops (non-integrated) unless otherwise specified. Slates/Tablets shall be configured in a manner identical to Notebooks unless otherwise specified. Portable All-In-One Computers shall be configured in a manner identical to Integrated Desktops unless otherwise specified.

1) Thin Clients shall run intended terminal/remote connection software during all tests.

B) Wake on LAN (WoL) settings shall be in as shipped condition for testing Sleep Mode and Off Mode.

C) For models that do not offer a Sleep Mode enabled by default, Section 6.2 shall measure power in the lowest-latency user-activated mode or state that preserves machine state and is enabled by default.

1) If no such state separate from Long Idle State or Off Mode exists, the measurement in Section 6.2 shall be skipped.

D) For Long Idle Mode Testing (Section 6.3), the UUT shall be allowed no more than 20 minutes from the point of ceased user input before measurements must be started. If any default settings cause the UUT to enter Long Idle after 20 minutes, begin taking measurements when the UUT has reached the 20 minute mark. Display sleep settings shall be set to default for Long Idle Mode Testing.

E) For Alternative Low Power Mode Testing (Section 6.3), the UUT shall be allowed no more than 20 minutes from the point of ceased user intput before measurements must be started. If any default settings cause the UUT to enter the Alternative Low Mode after 20 minutes, begin taking measurements when the UUT has reached the 20 minute mark. Display sleep settings shall be set to default for Alternative Low Power Mode Testing. When conducting the test in section 6.3, replace all instances of "Long Idle Mode" with "Alternative Low Power Mode.", and apply the definition of Alternative Low Power Mode from the ENERGY STAR Specification for Computers.

F) For Short Idle Mode Testing (Section 6.4), the UUT shall be allowed no more than five minutes from the point of ceased user input before measurements must be taken. Display sleep settings shall be disabled for Short Idle Mode Testing. If any other default settings cause the UUT to exit Short Idle during the measurement time, extend the settings so that the UUT remains in short idle for the duration of the measurement.

Additionally, only for notebook computers that demonstrate cyclical battery charging patterns, extend the short idle test long enough to capture the energy consumption over one or more complete cycles. The extended test shall be conducted by keeping the unit in short idle through minimal user input such as moving the mouse or pressing a key that does not perform any action (e.g. shift, ctrl, tab, etc). The UUT must remain in short idle during the entire time of the extended test.

Note: EPA and DOE did not receive any feedback on this topic. Accordingly, DOE intends to retain the approach of extending the short idle test with minimal user feedback as proposed.

G) Desktops, Integrated Desktops, Notebook Computers, Portable All-In-One Computers , and Slates/Tablets shall be tested for Idle, Sleep, and Off Mode with Full Network Connectivity ("Proxying") features using the as shipped setting.

H) Celluar network connections shall be disabled for testing. Additionally, Bluetooth should be left as-shipped.

I) If the UUT exhibits any cycling behavior and the normal measurement time would not capture one or more complete cycles, measure the long idle, alternative low power mode, sleep mode, and off mode measurement using an extended measurement capturing one or more full cycles per IEC 62301, section B.2.3.

J) Any secondary storage drive may have the power management features enabled during short idle as long as those power management features are enabled by default. A secondary storage drive refers to any drive that does not contain the operating system software.

5.2 Preparing Display Luminance of Notebooks, Integrated Desktops, Slates/Tablets and Portable All-In-One Computers

A) Before performing any tests, disable display dimming, display Sleep Mode, Computer Sleep Mode, and automatic brightness control (ABC) in the Computer settings. Document all settings that were changed from the default configuration.

1) If ABC cannot be disabled, position a light source such that at least 300 lux directly enters the ABC sensor.

B) Display the three vertical bar video signal as defined in section 3.2.1.3 of IEC 60107-1, "Methods of measurement on receivers for television broadcast transmissions – Part 1: General conditions – Measurements at radio and video frequencies" Edition 3.0, 1997 (IEC 60107-1 Ed. 3.0, 1997). The three bar image shall be configured using the default image display application.

C) Devices with a cold cathode fluorescent lamp (CCFL) backlight shall warm-up for at least 30 minutes. All other displays shall warm-up for at least 5 minutes.

D) With the LMD, measure the luminance in the center of the display.

E) Calibrate the UUT display brightness to the closest brightness setting that is at least 90 cd/m^2 for Notebook Computers, at least 150 cd/m^2 for Integrated Desktop Computers, Portable All-In-One Computers and Slates/Tablets. If the UUT's brightest setting cannot achieve the specified brightness, then set the UUT display to the brightest setting.

F) The display shall be configured with the ENERGY STAR test image, which can be found here[1]. For Desktops, Integrated Desktops, Notebook Computers and Portable All-In-One Computers it may be set as the "desktop background" (wallpaper) or shown via an image display application. The image shall be scaled to completely fill the display area. For Slates/Tablets, the display shall be configured with the default image display application.

G) Optional setting for units with multiple integrated displays. Configure all displays in the same way using the previous steps. The displays do not have to be configured sequentially (i.e. warmup times can be done simultaneously for all displays). For notebook computers, all displays must be set to the closest brightness setting that is at least 90 cd/m^2 for every display. For Integrated Desktop Computers, Portable All-In-One Computers and Slates/Tablets, all displays must be set to the closest brightness setting that is at least 150 cd/m^2 for every display.

H) For all testing specified in Section 6, the UUT shall not be rebooted or restarted until after the power measurements for Long Idle Mode and Short Idle Mode tests are taken.

[1] https://www.energystar.gov/ia/partners/images/ComputerTestingImage.bmp

I) Slate/Tablet and Portable All-In-One Computers shall be tested with a docking station only if it is shipped with the product and is the only way to power the device mains.

5.3 Preparing External Displays for Desktops

A) Display Connection Priority

1) If the UUT has a port that supports switchable graphics capable of automatic switching, use that port.
2) If a discrete GPU is installed, connect to that GPU, except for where it conflicts with Section 5.3 (A)(1) in this test method.
3) If no discrete or automatically switchable GPU is installed, choose a connection to an integrated GPU.
4) If multiple ports meet the requirements in Section 5.3 (A)(1) to 5.3 (A)(3) of this test method, test with the first available interface from the list below.

External Display Connection Priority
i. DisplayPort
ii. HDMI
iii. DVI
iv. VGA
v. Other (i.e. Thunderbolt 3)

Note: DOE has added a display connection priority to improve testing repeatability and uniformity. The proposed priority was in response to stakeholder input.

It is important to distinguish the connection protocol with the connection form factor. Alternate mode connection protocols have been created for various connection form factors. For example, USB-C can support DisplayPort, Thunderbolt 3, HDMI, and other protocols. And some DisplayPort interfaces can support the DisplayPort protocol and the Thunderbol 3 protocol. The connection priority listed above specifies the connection protocol rather than the form factor.

EPA and DOE request feedback on the priority order and whether there are other factors that should be considered in selecting a display connection when multiple interfaces exist.

A) Display Resolution:

An external monitor used in the testing of the UUT shall have a minimum native resolution of 1920X1080 pixels with progressive scanning (1080p). The UUT operating system shall be set to operate at a minimum of 1080p.

Note: EPA and DOE may consider updating a future specification and test method to reflect a 4K resolution display.

6 TEST PROCEDURES FOR ALL PRODUCTS

6.1 UUT Preparation

UUT preparation shall be performed according to IEC 62623, Ed.1.0, 2012-10, Section 5.2: Test Setup; with the additional guidance in Section 5 of this document.

6.2 Sleep Mode Testing

Sleep Mode power shall be measured according to IEC 62623, Ed.1.0, 2012-10, Section 5.3.3: Measuring Sleep Mode; with the additional guidance in Section 5 of this document.

6.3 Long Idle Mode Testing

Long Idle Mode power shall be measured according to IEC 62623, Ed.1.0, 2012-10, Section 5.3.4: Measuring Long Idle Mode; with the additional guidance in Section 5 of this document.

6.4 Short Idle Mode Testing

Short Idle Mode power shall be measured according to IEC 62623, Ed.1.0, 2012-10, Section 5.3.5: Measuring Short Idle Mode; with the additional guidance in Section 5 of this document.

6.5 Off Mode Testing

Off Mode power shall be measured according to IEC 62623, Ed.1.0, 2012-10, Section 5.3.2: Measuring Off Mode; with the additional guidance in Section 5 of this document.

6.6 Additional Testing For Reporting

For Notebook Computers, repeat the Short Idle test with the display brightness set to the closest setting that is at least 150 cd/m^2 for all displays.

7 TEST PROCEDURES FOR WORKSTATIONS

7.1 Maximum Power Test

The maximum power for Workstations is found by the simultaneous operation of two industry standard benchmarks: Linpack to stress the core system (e.g., processor, memory, etc.) and SPECviewperf® (latest available version for the UUT) to stress the system's Graphics Processing Unit (GPU). This test shall be repeated three times on the same UUT, and all three measurements shall fall within a ± 2% tolerance relative to the average of the three measured maximum power values. The average power should be used for qualification and/or TEC calculations.

Note: Workstations may certify configurations using Microsoft Windows® OS as a proxy for Linux for the maximum power test, as SPEC does not currently support a version of SPECviewperf® capable of running on the Linux OS.

Additional information on these benchmarks, including free downloads, can be found at the following locations as specified in Table 3.

Table 3: Benchmark Information for Maximum Power Test

Benchmark	Website
Linpack	http://www.netlib.org/linpack/
SPECviewperf	http://www.spec.org/benchmarks.html#gpc

A) UUT Preparation:

1) Connect a power meter capable of measuring true power to an ac line voltage source set to the appropriate voltage/frequency combination for the test. The meter shall have all the attributes listed in Section 4.1 E). The meter shall also store and output the maximum power measurement reached during the test or be capable of another method of determining maximum power.

2) Plug the UUT into the measurement power outlet on the meter. No power strips or uninterruptible power supply (UPS) units shall be connected between the meter and the UUT.

3) Record the ac voltage.

4) Boot the UUT and, if not already installed, install Linpack and SPECviewperf as indicated on the above Websites.

5) Set Linpack with all the defaults for the given architecture of the UUT and set the appropriate array size "n" for maximizing power draw during the test.

6) Ensure all technical guidelines relevant to running the benchmark set by the Standard Performance Evaluation Corporation (SPEC) organization for running SPECviewperf have been met.

7) For additional information regarding Linpack setup, see Section 9.1 Typical Linpack Starting Parameters.

B) Maximum Power Testing:

1) Set the meter to begin accumulating true power values at a rate greater than or equal to one reading per second, and begin taking measurements.

2) Run SPECviewperf and as many simultaneous instances of Linpack as needed to fully stress the system. Recommended setup information can be found in Section 9.1 C).

3) Accumulate power values until SPECviewperf and all Linpack instances have completed running. Record the maximum power value attained during the test.

4) The following data shall also be recorded:

a) Value of "n" (the array size) used for Linpack;

b) Number of simultaneous copies of Linpack run during the test;

c) Version of SPECviewperf run for test;

d) All compiler optimizations used in compiling Linpack and SPECviewperf; and

e) A precompiled binary for end users to download and run both SPECviewperf and Linpack. These can be distributed either through a centralized standards body such as SPEC, by the original equipment manufacturer (OEM), or by a related third party.

7.2 Benchmark Test

The benchmark test shall be performed by running both benchmarks listed below separately. The UUT shall be rebooted before testing with each benchmark. Additional information on these benchmarks, including downloads, can be found at the following locations specified in Table 4. All testing shall be performed with the latest available version of the benchmarks.

Table 4: Information for Benchmark Testing

Benchmark	Website
Linpack	http://www.netlib.org/linpack/
SPECviewperf	http://www.spec.org/benchmarks.html#gpc

A) UUT Preparation:

1) The UUT shall be setup identical to Step 1) through Step 4) of Section 7.1 A)

2) If not already installed, install the benchmark as indicated on the websites listed in Table 4.

3) Configure the benchmark as specified in Section 7.2 B).

4) Time Measurement: Time measurements may be performed with a standard stopwatch or other time keeping device with a resolution of at least 1 second.

B) Benchmark Configurations:

1) Linpack

a) Configure the Linpack settings identically to the maximum power workstation test (e.g. Follow Step 5) and Step 7) of Section 7.1 A)).

b) Run as many simultaneous instances of Linpack as needed to fully stress the system. Recommended settings would be to set the number of simultaneous instances of Linpack equal to the number of logical and/or physical CPU cores of the system.

2) SPECviewperf

a) Configure the settings identically to the maximum power workstation test (e.g. Follow Step 6) of Section 7.1 A)).

C) Benchmark Testing:

1) Set the meter to begin accumulating true power values at a rate of greater than or equal to one reading per second and begin power and time measurement.

2) Execute the benchmark.

3) Stop time measurement and accumulate power values for the entire duration of the benchmark run.

4) The following data shall be reported:

a) Linpack

i. Value of “n” (the array size) used for Linpack;

ii. Number of instances of Linpack simultaneously run on the system;

iii. All compiler options used in compiling Linpack;

iv. Energy consumed over the duration of the test; and

v. Linpack output file in text format which contains system performance in floating point operations per second (Flops) in addition to other Linpack parameters (e.g. number of tests, problem size, etc.).

b) SPECviewperf

i. Version of SPECviewperf used;

ii. All compiler optimizations used in compiling SPECviewperf;

iii. Duration of the test;

iv. Energy consumed over the duration of the test; and

v. All files and folders present in the Result folder of SPECviewperf suite shall be reported.

8 REFERENCES

A) IEC 62301 Edition 2.0 2011-01, Household electrical appliances – Measurement of standby power.

B) IEC 60107-1 Edition 3.0 1197-04, Methods of measurement on receivers for television broadcast transmissions – Part 1: General Considerations – Measurements at radio and video frequencies.

C) IEC 62623 Edition 1.0 2012-10, Desktop and notebook computers – Measurement of energy consumption

9 APPENDIX: BENCHMARK PARAMETERS

9.1 Typical Linpack Starting Parameters

Below are some typical starting values for the use of Linpack for testing Workstations. These values are starting points and not meant to be binding. The tester is free to use the settings most advantageous to their UUT. Platform and Operating System (OS) will have a significant impact on the applicability of these starting values. The below assumes Linux as the test OS.

A) Number of equations (problem size): See Equation.

B) Leading dimensions of array: See Equation.

The matrix size (the combination of number of equations and leading dimensions of array) should be the maximum size that will fit in the Random Access Memory (RAM) on the machine. This AWK script will calculate matrix size on a Linux machine:

```
awk '
    BEGIN {
        printf "Maximum matrix dimension that will fit in RAM on this machine: "
    }
    /^MemTotal:/ {
        print int(sqrt(($2*1000)/8)/1000) "K"
    }
' /proc/meminfo
```

Use the output of this to determine what matrix size to input for both the "Number of equations" and "Leading dimensions of array" inputs. The “Number of equations” will be equal to the printed output. The “Leading dimensions of the array” will be the output rounded up to the nearest multiple of eight.

This calculation can be most easily calculated by taking the memory size, in bytes, of the UUT (denoted as m) and substituting m in Equation 1.

$$\frac{\sqrt{\frac{m \times 1000}{8}}}{1000}$$

Equation 1: Memory Size Calculation

C) *Number of trials*: c - 1 where c equals the number of logical and/or physical CPU cores of the system. The tester needs to determine which is more advantageous for the unit. The -1 leaves one core open for use by SPECviewperf.

D) *Data alignment value*: Typically four with Linux systems. The best value to use is the page size boundary of the OS.