



ENERGY STAR® Program Requirements for Displays

Partner Commitments

Following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacture and labeling of ENERGY STAR certified products. The ENERGY STAR Partner must adhere to the following partner commitments:

Certifying Products

1. **Comply with current ENERGY STAR Eligibility Criteria**, which define performance requirements and test procedures for displays. A list of eligible products and their corresponding Eligibility Criteria can be found at www.energystar.gov/specifications.
2. **Prior to associating the ENERGY STAR name or mark with any product**, obtain written certification of ENERGY STAR certification from a Certification Body recognized by EPA for displays. As part of this certification process, products must be tested in a laboratory recognized by EPA to perform displays testing. A list of EPA-recognized laboratories and certification bodies can be found at www.energystar.gov/testingandverification.
3. **Ensure that any model associated with the ENERGY STAR name or mark** meets the following standards:
 - 3.1. Product material requirements as defined in restriction of hazardous substances (RoHS) regulations, as generally accepted. This includes exemptions in force at the date of product manufacture, where the maximum concentration values tolerated by weight in homogeneous materials are: lead (0.1%), mercury (0.1%), cadmium (0.01%), hexavalent chromium (0.1%), polybrominated biphenyls (PBB) (0.1%), polybrominated diphenyl ethers (PBDE) (0.1%), bis(2-ethylhexyl) phthalate (DEHP) (0.1%), benzyl butyl phthalate (BBP) (0.1%), dibutyl phthalate (DBP) (0.1%), or diisobutyl phthalate (DIBP) (0.1%). Batteries are exempt.
 - 3.2. The generally accepted attributes of a recyclable product at the date of product manufacture: where products shall be designed for ease of disassembly and recyclability where external enclosures, sub-enclosures, chassis and electronic subassemblies are easily removable with commonly available tools, by hand, or by a recycler's automated processes.

Notes:

- The explicit intention is to harmonize with EU RoHS.
- For purposes of ENERGY STAR third-party certification, these requirements shall not be reviewed when products are initially certified nor during subsequent verification testing. Rather, EPA reserves the right to request supporting documentation at any time.

Using the ENERGY STAR Name and Marks

4. Comply with current ENERGY STAR Brand Book, which define how the ENERGY STAR name and marks may be used. Partner is responsible for adhering to these guidelines and ensuring that its authorized representatives, such as advertising agencies, dealers, and distributors, are also in compliance. The ENERGY STAR Brand Book are available at www.energystar.gov/logouse.
5. Use the ENERGY STAR name and marks only in association with certified products. Partner may not refer to itself as an ENERGY STAR Partner unless at least one product is certified and offered for sale in the U.S. and/or ENERGY STAR partner countries.
6. Provide clear and consistent labeling of ENERGY STAR certified displays.

6.1. Partner shall adhere to the following product-specific commitments regarding use of the ENERGY STAR certification mark on certified products:

6.1.1. Partner must use the ENERGY STAR mark in one of the following ways:

- 1) On the top or front of the product. Labeling on the top or front of the product may be permanent or temporary. All temporary labeling must be affixed to the top or front of the product with an adhesive or cling-type application;
- 2) Via electronic labeling displayed on the screen such that the ENERGY STAR mark must be at least 10% of the screen by area; may not be smaller than 76 pixels x 78 pixels; must be legible; must be in cyan, black, or white; and either
 - a. Must appear at system start-up, and must display for a minimum of 5 seconds; or
 - b. Must appear within the display settings dialog window. EPA will consider alternative proposals for electronic labeling on a case-by-case basis.

6.1.2. Partner must use the ENERGY STAR mark in product literature (i.e., user manuals, specification sheets, etc.);

6.1.3. Partner must use the ENERGY STAR mark on product packaging for products sold at retail; and

6.1.4. Partner must use the ENERGY STAR mark on the Partner's Internet site where information about ENERGY STAR certified models is displayed:

- 1) If information concerning ENERGY STAR is provided on the Partner website, as specified by the ENERGY STAR Web Linking Policy, which can be found in the Partner Resources section on the ENERGY STAR website at www.energystar.gov/partners.

Verifying Ongoing Product Certification

7. Participate in third-party verification testing through a certification body recognized by EPA for displays, providing full cooperation and timely responses. EPA/DOE may also, at its discretion, conduct tests on products that are referred to as ENERGY STAR certified. These products may be obtained on the open market, or voluntarily supplied by Partner at the government's request.

Providing Information to EPA

8. Provide unit shipment data or other market indicators to EPA annually to assist with creation of ENERGY STAR market penetration estimates, as follows:

- 8.1. Partner must submit the total number of ENERGY STAR certified displays shipped in the calendar year or an equivalent measurement as agreed to in advance by EPA and Partner. Partner shall exclude shipments to organizations that rebrand and resell the shipments (unaffiliated private labelers).
- 8.2. Partner must provide unit shipment data segmented by meaningful product characteristics (e.g., type, capacity, presence of additional functions) as prescribed by EPA.
- 8.3. Partner must submit unit shipment data for each calendar year to EPA or an EPA-authorized third party, preferably in electronic format, no later than March 1 of the following year.

Submitted unit shipment data will be used by EPA only for program evaluation purposes and will be closely controlled. If requested under the Freedom of Information Act (FOIA), EPA will argue that the data is exempt. Any information used will be masked by EPA so as to protect the confidentiality of the Partner;

9. Report to EPA any attempts by recognized laboratories or Certification Bodies (CBs) to influence testing or certification results or to engage in discriminatory practices.

10. Notify EPA of a change in the designated responsible party or contacts within 30 days using the My ENERGY STAR Account tool (MESA) available at www.energystar.gov/mesa.

Performance for Special Distinction

In order to receive additional recognition and/or support from EPA for its efforts within the Partnership, the ENERGY STAR Partner may consider the following voluntary measures, and should keep EPA informed on the progress of these efforts:

- Provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase availability of ENERGY STAR certified products, and to promote awareness of ENERGY STAR and its message.
- Consider energy efficiency improvements in company facilities and pursue benchmarking buildings through the ENERGY STAR Buildings program.
- Purchase ENERGY STAR certified products. Revise the company purchasing or procurement specifications to include ENERGY STAR. Provide procurement officials' contact information to EPA for periodic updates and coordination. Circulate general ENERGY STAR certified product information to employees for use when purchasing products for their homes.
- Feature the ENERGY STAR mark(s) on Partner website and other promotional materials. If information concerning ENERGY STAR is provided on the Partner website as specified by the ENERGY STAR Web Linking Policy (available in the Partner Resources section of the ENERGY STAR website), EPA may provide links where appropriate to the Partner website.
- Ensure the power management feature is enabled on all ENERGY STAR certified displays and computers in use in company facilities, particularly upon installation and after service is performed.
- Provide general information about the ENERGY STAR program to employees whose jobs are relevant to the development, marketing, sales, and service of current ENERGY STAR certified products.
- Provide a simple plan to EPA outlining specific measures Partner plans to undertake beyond the program requirements listed above. By doing so, EPA may be able to coordinate, and communicate Partner's activities, provide an EPA representative, or include news about the event in the ENERGY STAR newsletter, on the ENERGY STAR website, etc. The plan may be as simple as providing a list of planned activities or milestones of which Partner would like EPA to be aware. For example, activities may include: (1) increasing the availability of ENERGY STAR certified products by converting the entire product line within two years to meet ENERGY STAR guidelines; (2) demonstrating the economic and environmental benefits of energy efficiency through special in-store displays twice a year; (3) providing information to users (via the website and user's manual) about energy-saving features and operating characteristics of ENERGY STAR certified products; and (4) building awareness of the ENERGY STAR Partnership and brand identity by collaborating with EPA on one print advertorial and one live press event.
- Join EPA's SmartWay Transport Partnership to improve the environmental performance of the company's shipping operations. The SmartWay Transport Partnership works with freight carriers, shippers, and other stakeholders in the goods movement industry to reduce fuel consumption, greenhouse gases, and air pollution. For more information on SmartWay, visit www.epa.gov/smartway.
- Join EPA's Green Power Partnership. EPA's Green Power Partnership encourages organizations to buy green power as a way to reduce the environmental impacts associated with traditional fossil fuel-based electricity use. The partnership includes a diverse set of organizations including Fortune 500 companies, small and medium businesses, government institutions as well as a growing number of colleges and universities. For more information on Green Power, visit www.epa.gov/greenpower.



ENERGY STAR® Program Requirements Product Specification for Displays

Eligibility Criteria Version 8.0

Following is the Version 8.0 ENERGY STAR product specification for Displays. A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

1 DEFINITIONS

A) Product Types:

- 1) Electronic Display (Display): A product with a display screen and associated electronics, often encased in a single housing, that as its primary function produces visual information from (1) a computer, workstation, or server via one or more inputs (e.g., VGA, DVI, HDMI, DisplayPort, IEEE 1394, USB), (2) external storage (e.g., USB flash drive, memory card), or (3) a network connection.
 - a) Monitor: An Electronic Display intended for one person to view in a desk-based environment.
 - b) Signage Display: An Electronic Display intended for multiple people to view in non-desk-based environments, such as retail or department stores, restaurants, museums, hotels, outdoor venues, airports, conference rooms or classrooms. For the purposes of this specification, a Display shall be classified as a Signage Display if it meets three or more criteria listed below:
 - (1) Diagonal screen size is greater than 30 inches;
 - (2) Maximum Reported Luminance is greater than 400 candelas per square meter;
 - (3) Pixel density is less than or equal to 7,000 pixels per square inch;
 - (4) Ships without a mounting stand designed to support the display on a desktop; or
 - (5) Contains RJ45 or RS232 physical ports.
 - c) Tiled Display System: A testable configuration of Signage Displays in which multiple Signage Displays are tiled together contiguously and supported by one or more modular external controllers and one or more modular external power supplies to produce a single larger image.
 - (1) Maximum Tiled Configuration: A Tiled Display System configured with the maximum number of Signage Display panels supported by the same set of external support modules (e.g., power supplies, controllers, etc.) that are needed to support a configuration with two panels.

B) Operational Modes:

- 1) On Mode: The mode in which the Display has been activated and is providing the primary function.
- 2) Sleep Mode: A low-power mode in which the Display provides one or more non-primary protective functions or continuous functions.

Note: Sleep Mode may serve the following functions: facilitate the activation of On Mode via remote switch, Touch Technology, internal sensor, or timer; provide information or status displays including clocks; support sensor-based functions; or maintain a network presence.

- 3) **Off Mode:** The mode where the Display is connected to a power source, produces no visual information, and cannot be switched into any other mode with the remote control unit, an internal signal, or an external signal.

Note: The Display may only exit this mode by direct user actuation of an integrated power switch or control. Some products may not have an Off Mode.

C) **Displays Settings and Menus**

- 1) **Preset Picture Setting:** A preprogrammed factory setting obtained from the Display menu with pre-determined picture parameters such as brightness, contrast, color, sharpness, etc.
- 2) **Default Picture Setting:** The Preset Picture Setting tested and recognized according to the ENERGY STAR test method. The Default Picture Setting is typically the Preset Picture Setting in the model's as-shipped default state. If the Display has a Forced Menu, the Default Picture Setting is the Preset Picture Setting identified according to the ENERGY STAR test method, usually the setting labeled "Standard" or "Home."
- 3) **Forced Menu:** A series of menus which require the selection of initial settings before allowing the user to utilize primary functions. These menus may contain an option to select between the Default Picture Setting and other picture settings not tested in the ENERGY STAR test method.

Note: In the case that no standard setting or equivalent exists, the default setting recommended by the manufacturer is considered the Default Picture Setting for the purposes of this specification.

D) **Visual Characteristics:**

- 1) **Ambient Light Conditions:** The combination of light illuminances in the environment surrounding a Display, such as a living room or an office.
- 2) **Automatic Brightness Control (ABC):** The self-acting mechanism that controls the brightness of a Display as a function of Ambient Light Conditions.

Note: ABC functionality must be enabled to control the brightness of a Display.
- 3) **Color Gamut:** The range of color supported within the CIE LUV 1976 u' v' color space and calculated per Section 5.18 Gamut Area of the Information Display Measurements Standard Version 1.03.

Note: Any gamut support in non-visible/invisible color areas is not to be counted. The gamut must be expressed as a percentage from 1% to 100% to the nearest 0.1% of the area of the visible CIE LUV color space only.
- 4) **High Dynamic Range (HDR):** The ability to display images with greater range of contrast and color than what is considered standard dynamic range.
- 5) **Luminance:** The photometric measure of the luminous intensity per unit area of light travelling in a given direction, expressed in candelas per square meter (cd/m^2).
 - a) **Maximum Reported Luminance:** The maximum luminance the Display may attain at an On Mode preset setting, and as specified by the manufacturer, for example, in the user manual.
 - b) **Maximum Measured Luminance:** The maximum measured luminance the Display may attain by manually configuring its controls, such as brightness and contrast.
 - c) **As-shipped Luminance:** The luminance of the Display at the factory default preset setting the manufacturer selects for normal home or applicable market use.
- 6) **Total Native Resolution:** Resolution expressed as total pixel count in megapixels calculated as the product of physical lines along the vertical and horizontal axes of the Display within the visible area of the Display.

Note: A Display with a screen resolution of 1920 x 1080 (horizontal x vertical) would have a Total Native Resolution of 2.07 megapixels (MP).

- 7) Screen Area: The visible area of the Display that produces images.

Note: Screen Area is calculated by multiplying the viewable image width by the viewable image height. For curved screens, measure the width and height along the arc of the Display.

E) Additional Functions and Features:

- 1) Bridge Connection: A physical connection between two hub controllers (e.g. USB, FireWire).

Note: Bridge Connections allow for expansion of ports typically for the purpose of relocating the ports to a more convenient location or increasing the number of available ports.

- 2) Full Network Connectivity: The ability of the Display to maintain network presence while in Sleep Mode. Presence of the Display, its network services, and its applications, is maintained even if some components of the Display are powered down. The Display can elect to change power states based on receipt of network data from remote network devices but should otherwise stay in Sleep Mode absent a demand for services from a remote network device.

Note: Full Network Connectivity is not limited to a specific set of protocols. Also referred to as “network proxy” functionality and described in the Ecma-393 standard.

- 3) Power Delivery: The capability, defined according to the USB Power Delivery Specification,¹ of the Display to supply variable power as well as exchange data with devices connected via a USB connection.

- 4) Occupancy Sensor: A device used to detect human presence in front of or in the area surrounding a Display.

Note: An Occupancy Sensor is typically used to switch a Display between On Mode and Sleep Mode by detecting human presence or a combination of human presence and a signaling device such as Bluetooth device.

- 5) Touch Technology: Enables the user to interact with a product by touching areas on the Display screen.

- 6) Plug-in Module: A modular plugin device for Signage Displays with compute functionality that provides one or more of the following functions:

- a) Display remote content streamed to it, such as images or screen mirroring, or otherwise render content on the screen from local or remote sources; or
- b) Process touch signals.

Note: Modules providing any other additional input options are not considered Plug-in Modules for the purposes of this specification. Modules typically meet the Open Pluggable Specification (OPS).

- 7) Embedded Module: A non-modular processor or computing system embedded in a Signage Display that provides one or more of the following functions:

- a) Display remote content streamed to it, such as images or screen mirroring, or otherwise render content on the screen from local or remote sources; or
- b) Process touch signals.

¹ USB Power Delivery Specification Rev. 3.0, Version 1.2, June 21, 2018.

- F) Product Family: A group of product models that (1) are made by the same manufacturer, (2) share the same Screen Area, Total Native Resolution, and Maximum Reported Luminance, and (3) are of a common basic screen design. Models within a Product Family may differ from each other according to one or more characteristics or features. For Displays, acceptable variations within a Product Family include:
- 1) External housing;
 - 2) Number and types of interfaces;
 - 3) Number and types of data, network, or peripheral ports; and
 - 4) Processing and memory capability.
- G) Representative Model: The product configuration that is tested for ENERGY STAR certification and is intended to be marketed and labeled as ENERGY STAR.
- H) Power Sources:
- 1) External Power Supply (EPS): An external power supply circuit that is used to convert household electric current into dc current or lower-voltage ac current to operate a consumer product.
 - 2) Standard dc: A method for transmitting dc power defined by a well-known technology standard, enabling plug-and-play interoperability.
- Note: Common examples are USB and Power-over-Ethernet. Usually Standard dc includes both power and communications over the same cable, but as with the 380 V dc standard, that is not required.

2 SCOPE

2.1 Included Products

- 2.1.1 Products that meet the definition of a Display as specified herein and are powered directly from ac mains, an External Power Supply, or Standard dc are eligible for ENERGY STAR certification, with the exception of products listed in Section 2.2. Typical products that would be eligible for certification under this specification include:
- i. Monitors;
 - ii. Signage Displays;
 - iii. Signage Displays with Plug-in Modules;
 - iv. Signage Displays with Embedded Modules; and
 - v. Signage Displays in a Tiled Display System configuration.

2.2 Excluded Products

- 2.2.1 Products that are covered under other ENERGY STAR product specifications are not eligible for certification under this specification including Televisions and Computers (Thin Clients, Slates/Tablets, Portable All-in-one Computers, and Integrated Desktops). The list of specifications currently in effect can be found at www.energystar.gov/products.
- 2.2.2 The following products are not eligible for certification under this specification:
- i. Products with an integrated television tuner;

- ii. Displays with integrated or replaceable batteries designed to support primary operation without ac mains or external dc power, or device mobility (e.g., electronic readers, battery-powered digital picture frames); and
- iii. Products that must meet Food and Drug Administration specifications for medical devices that prohibit power management capabilities and/or do not have a power state meeting the definition of Sleep Mode.
- vi. Monitors with keyboard, video, and mouse (KVM) switch functionality;

3 CERTIFICATION CRITERIA

3.1 Significant Digits and Rounding

- 3.1.1 All calculations shall be carried out with directly measured (unrounded) values.
- 3.1.2 Unless otherwise specified, compliance with specification requirements shall be evaluated using directly measured or calculated values without any benefit from rounding.
- 3.1.3 Directly measured or calculated values that are submitted for reporting on the ENERGY STAR website shall be rounded to the nearest significant digit as expressed in the corresponding specification requirements.

3.2 General Requirements for Monitors and Signage Displays

- 3.2.1 External Power Supplies (EPSs): Single- and Multiple-voltage EPSs shall meet the Level VI or higher performance requirements under the International Efficiency Marking Protocol when tested according to the Uniform Test Method for Measuring the Energy Consumption of External Power Supplies, Appendix Z to 10 CFR Part 430.
 - i. Single- and Multiple-voltage EPSs shall include the Level VI or higher marking.
 - ii. Additional information on the Marking Protocol is available at <http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0005-0218>.
- 3.2.2 General User Information: The product shall ship with consumer informational materials located in either (1) the hard copy or electronic user manual, or (2) a package or box insert. These materials shall include:
 - a) Information about the ENERGY STAR program,
 - b) Information on the energy consumption implications of changes to default as-shipped displays configuration and settings, and
 - c) Notification that enabling certain optional features and functionalities (e.g., instant-on), may increase energy consumption beyond the limits required for ENERGY STAR certification, as applicable.
- 3.2.3 Forced Menu: Any product that includes a Forced Menu upon initial start-up shall upon selection of any mode other than the Default Picture Setting as identified and tested by the ENERGY STAR test procedure either (1) display a second prompt requiring the user to confirm the choice of the other mode, or (2) display information either with the ENERGY STAR mark or copy on the start-up menu that the Default Picture Setting is the setting in which the product qualifies for ENERGY STAR.

- 3.2.4 Preset Picture Setting Menu: For any product where consumers have the option of selecting different picture settings from a preset menu at any time:
- a) The product shall identify on-screen the Default Picture Setting under which the product qualifies for the ENERGY STAR, if available. For example, the product may display an electronic ENERGY STAR mark alongside the name or description of that Default Picture Setting or display a message each time any setting other than the Default Picture Setting is selected.
 - b) The product shall return to the identified Default Picture Setting, including all energy saving features enabled by default, whenever the user selects that Preset Picture Setting.
- 3.2.5 Sleep Mode Settings: If users can select and enable Sleep Mode functions from a display prompt in On Mode or a settings menu other than a Forced Menu, and if these functions may alter power draw (i.e. quick start) from the default as-shipped Sleep Mode in which the product qualifies for the ENERGY STAR:
- a) The product shall display on-screen information identifying the settings under which the product qualifies for the ENERGY STAR. For example, such information may be indicated by including an electronic ENERGY STAR mark alongside the name or description of the default as-shipped settings or in the form of a message displayed each time any setting other than a default as-shipped setting is selected.
 - b) Products with a physical ENERGY STAR mark affixed to the front or top of the Display may alternatively display on-screen information that enabling settings other than those under which the product qualifies for the ENERGY STAR may change the energy consumption of the product.
- 3.2.6 Power Management:
- i. Products shall offer at least one power management feature that is enabled by default, and that can be used to automatically transition from On Mode to Sleep Mode either by a connected host device or internally (e.g., support for VESA Display Power Management Signaling (DPMS), enabled by default).
 - ii. Products that generate content for display from one or more internal sources shall have a sensor or timer enabled by default to automatically engage Sleep or Off Mode.
 - iii. For products that have an internal default delay time after which the product transitions from On Mode to Sleep Mode or Off Mode, the delay time shall be reported.
 - iv. Monitors shall automatically enter Sleep Mode or Off Mode within 5 minutes of being disconnected from a host computer.
- 3.2.7 Signage Displays shall have a true power factor in On Mode of 0.7 or greater per Section 5.2.F in the ENERGY STAR Test Method.

3.3 Energy Requirements for Computer Monitors

- 3.3.1 The Total Energy Consumption (TEC) in kWh shall be calculated per Equation 1 based on measured values.

Equation 1: Total Energy Consumption Calculation

$$E_{TEC} = 8.76 \times (0.35 \times P_{ON} + 0.65 \times P_{SLEEP})$$

Where:

- E_{TEC} is the Total Energy Consumption calculation in kWh;
- P_{ON} is Measured On Mode power in watts
- P_{SLEEP} is Measured Sleep Mode Power in watts; and
- The result shall be rounded to the nearest tenth of a kWh for reporting.

3.3.2 The Maximum TEC (E_{TEC_MAX}) in kWh for Monitors shall be calculated per Table 1.

Table 1: Calculation of Maximum TEC (E_{TEC_MAX}) for Monitors in kWh

Area (in ²)	E_{TEC} Max (kWh)
	Where: A = Viewable screen area in in ² r = Screen resolution in megapixels (MP) The result shall be rounded to the nearest tenth of a kWh for reporting.
A < 190	$(4.00 \times r) + (0.172 \times A) + 1.50$
$190 \leq A < 210$	$(4.00 \times r) + (0.020 \times A) + 30.40$
$210 \leq A < 315$	$(4.00 \times r) + (0.091 \times A) + 15.40$
A ≥ 315	$(4.00 \times r) + (0.182 \times A) - 13.20$

3.3.3 For all Monitors, Calculated TEC (E_{TEC}) in kWh shall be less than or equal the calculation of Maximum TEC (E_{TEC_MAX}) with the applicable allowances and adjustments (each applied at most once) per Equation 2.

Equation 2: Total Energy Consumption Requirement for Monitors

$$E_{TEC} \leq (E_{TEC_MAX} + E_{EP} + E_{ABC} + E_N + E_T + E_C + E_{HDR} + E_{USB}) \times eff_{AC_DC}$$

Where:

- E_{TEC} is TEC in kWh calculated per Equation 1;
- E_{TEC_MAX} is the Maximum TEC requirement in kWh calculated per Table 1;
- E_{EP} is the enhanced performance display allowance in kWh per Section 3.3.4;
- E_{ABC} is the Automatic Brightness Control allowance in kWh per Equation 5;
- E_N is the Full Network Connectivity allowance in kWh per Table 2;
- E_T is the Touch Technology allowance in kWh per Equation 6;
- E_C is the curved Display allowance in kWh per Equation 7;
- E_{HDR} is the HDR Display allowance in kWh per Table 3;
- E_{USB} is the allowance for Displays with USB-C Power Delivery functionality per Table 4; and
- eff_{AC_DC} is the standard adjustment for ac-dc power conversion losses that occur at the device powering the Display and is 1.0 for Ac-powered Displays and 0.85 for Displays with Standard dc.

3.3.4 For Monitors meeting the enhanced performance display (EPD) requirements below, the energy allowance in Equation 3 shall be applied to the Total Energy Consumption requirement in Equation 2:

- i. Contrast ratio of at least 60:1 measured at a horizontal viewing angle of at least 85° from the perpendicular on a flat screen and at least 83° from the perpendicular on a curved screen, with or without a screen cover glass;
- ii. A native resolution greater than or equal to 2.3 megapixels (MP); and
- iii. Color Gamut greater than or equal to 32.9% of CIE LUV.

Equation 3: Calculation of Energy Allowance for Enhanced Performance Displays

$$E_{EP} = \left((1.70 \times \frac{G}{100\%}) - 0.52 \right) * E_{TEC_MAX}$$

Where:

- E_{EP} is the enhanced performance display energy allowance in kWh;
- G is Color Gamut expressed as a percentage of CIE LUV from 1.0% to 100.0%, reported to the nearest 0.1%; and
- E_{TEC_MAX} is the Maximum TEC requirement in kWh calculated per Equation 2.

Note: For reference, a model supporting 99% of the sRGB color space typically translates to 32.9% of CIE LUV and a model supporting 99% of Adobe RGB typically translates to 38.4% of CIE LUV.

- 3.3.5 For monitors with Automatic Brightness Control (ABC) enabled by default, an energy allowance (E_{ABC}), as calculated per Equation 5, shall be added to E_{TEC_MAX} in Equation 2, if the On Mode power reduction (R_{ABC}), as calculated per Equation 4, is greater than or equal to 20%.

Equation 4: Calculation of On Mode Reduction with ABC Enabled by Default

$$R_{ABC} = 100\% \times \left(\frac{P_{300} - P_{12}}{P_{300}} \right)$$

Where:

- R_{ABC} is the On Mode percent power reduction due to ABC;
- P_{300} is the On Mode power in watts, as measured at an ambient light level of 300 lux in Section 6.4 of the Test Method; and
- P_{12} is the On Mode power in watts, as measured at an ambient light level of 12 lux in Section 6.4 of the Test Method.

Equation 5: ABC Energy Allowance (E_{ABC}) for Monitors

$$E_{ABC} = 0.05 \times E_{TEC_MAX}$$

Where:

- E_{ABC} is the energy allowance for Automatic Brightness Control in kWh; and
- E_{TEC_MAX} is the Maximum TEC in kWh, per Table 1.

- 3.3.6 Products with Full Network Connectivity confirmed in Section 6.7 of the ENERGY STAR Test Method shall apply the allowance specified in Table 2.

Table 2: Full Network Connectivity Energy Allowance (E_N) for Monitors

E_N (kWh)
2.9

- 3.3.7 Products tested with Touch Technology active in On Mode shall apply the allowance specified in Equation 6.

Equation 6: Energy Allowance for Touch Technology (E_T) for Monitors

$$E_T = 0.17 \times E_{TEC_MAX}$$

Where:

- E_T is the energy allowance for Touch Technology in kWh; and
- E_{TEC_MAX} is the Maximum TEC in kWh, per Table 1.

3.3.8 Products tested with curved Displays shall apply the allowance specified in Equation 7.

Equation 7: Monitors Curved Display Energy Allowance (E_C) for Monitors

$$E_C = 0.15 \times E_{TEC_MAX}$$

Where:

- E_C is the energy allowance for curved Displays in kWh; and
- E_{TEC_MAX} is the Maximum TEC in kWh, per Table 1.

3.3.9 Monitors that meet either the following DisplayHDR 600 or DisplayHDR 1000 White Luminance Criteria specified in Table 2-1: DisplayHDR Performance Tier Summary of the Video Electronics Standards Association (VESA) High-performance Monitor and Display Compliance Test Specification (DisplayHDR CTS) Version 1.0 shall apply the allowance specified in Table 3.

- a) 10% Center Patch Minimum Requirement (cd/m²);
- b) Full-screen Flash Minimum Requirement (cd/m²); and
- c) Full-screen Long-duration Minimum Requirement (cd/m²).

Table 3: HDR 600 and HDR 1000 Energy Allowances for Monitors

VESA DisplayHDR Certification	E_{HDR} (kWh)
HDR 600	$0.05 \times E_{TEC_MAX}$
HDR 1000	$0.10 \times E_{TEC_MAX}$

Where:

- E_{HDR} is the allowance for models meeting the DisplayHDR CTS tiers 600 or 1000; and
- E_{TEC_MAX} is the Maximum TEC per Table 1.

3.3.10 Products with USB Type C interface compatibility capable of delivering greater than or equal to 45 W of power to connected devices shall apply the allowance specified in Table 4.

Table 4: Allowance for Monitors with USB Type C Compatibility

E_{USB} (kWh)
2.75

Where:

- E_{USB} is the allowance for models with USB Type C Power Delivery compatibility.

3.4 Signage Displays Tested in a Tiled Display System Configuration

3.4.1 Signage Displays marketed, shipped, and tested in a Tiled Display System configuration shall meet the Signage Display On Mode and Sleep Mode criteria as calculated per Equation 9 and Equation 11, in which the Screen Area used for all such calculations shall be the total screen area of the Maximum Tiled Configuration.

Note: The total Screen Area of a Tiled Display System with a Maximum Tiled Configuration of 2x2 individual 47.6-inch diagonal Signage Displays (height 23.3 inches and length 41.5 inches) is calculated as (2 x 23.3") x (2 x 41.5") equal to 3867.8 square inches. The Tiled Display System shall meet the On Mode criteria for a 3,867.8 square inch Signage Display.

3.5 On Mode Requirements for Signage Displays

3.5.1 The maximum On Mode power (P_{ON_MAX}) in watts shall be calculated per Equation 8.

Equation 8: Calculation of Maximum On Mode Power (P_{ON_MAX}) in Watts for Signage Displays

$$P_{ON_MAX} = (4.0 \times 10^{-5} \times \ell \times A) + 120 \times \tanh(0.0005 \times (A - 140.0) + 0.03) + 20$$

Where:

- P_{ON_MAX} is the Maximum On Mode power, in watts;
- A is the Screen Area in square inches;
- ℓ is the Maximum Measured Luminance of the Display in candelas per square meter, as measured in Section 6.2 of the test method; and
- The result shall be rounded to the nearest tenth of a watt for reporting.

Equation 9: On Mode Power Requirement for Signage Displays

$$P_{ON} \leq P_{ON_MAX} + P_{ABC} + P_{Module}$$

Where:

- P_{ON} is On Mode power in watts, as measured in Section 6.3 or 6.4 of the Test Method;
- P_{ON_MAX} is the Maximum On Mode power in watts, per Equation 8; and
- P_{ABC} is the On Mode power allowance for ABC in watts, per Equation 10; and
- P_{Module} is the On Mode power allowance for Signage Displays with Embedded or Plug-In Modules as specified in Table 5.

3.5.2 For Signage Displays with ABC enabled by default, a power allowance (P_{ABC}), as calculated per Equation 10, shall be added to P_{ON_MAX} , as calculated per Equation 9, if the On Mode power reduction (R_{ABC}), as calculated per Equation 4, is greater than or equal to 20 percent.

Equation 10: Calculation of On Mode Power Allowance for Signage Displays with ABC Enabled by Default

$$P_{ABC} = 0.05 \times P_{ON_MAX}$$

Where:

- P_{ABC} is the Measured On Mode Power allowance for ABC in watts; and
- P_{ON_MAX} is the Maximum On Mode Power requirement in watts.

3.5.3 For Signage Displays with an Embedded Module, a power allowance (P_{Module}) determined by Table 5 shall be added to P_{ON_MAX} , as calculated per Equation 9.

Table 5: On Mode Power Allowance for Signage Displays with an Embedded Module

P_{Module} (W)
2.5

Where:

- P_{Module} is the Measured On Mode power allowance for Embedded Modules in Watts.

3.6 Sleep Mode Requirements for Signage Displays

3.6.1 Measured Sleep Mode power (P_{SLEEP}) in watts shall be less than or equal the sum of the Maximum Sleep Mode power requirement (P_{SLEEP_MAX}) and any allowances (applied at most once) per Equation 11.

Equation 11: Sleep Mode Power Requirement for Signage Displays

$$P_{SLEEP} \leq P_{SLEEP_MAX} + P_N + P_{OS} + P_T$$

Where:

- P_{SLEEP} is Measured Sleep Mode power in watts;

- P_{SLEEP_MAX} is the Maximum Sleep Mode power requirement in watts per Table 6;
- P_N is the Full Network Connectivity allowance in watts per Table 7;
- P_{OS} is the Occupancy Sensor allowance in watts per Table 8; and
- P_T is the Touch allowance in watts per Table 8.

Table 6: Maximum Sleep Mode Power Requirement (P_{SLEEP_MAX}) for Signage Displays

P_{SLEEP_MAX} (watts)
0.5

3.6.2 Products with Full Network Connectivity confirmed in Section 6.7 of the ENERGY STAR Test Method shall apply the allowance specified in Table 7.

Table 7: Full Network Connectivity Allowance for Signage Displays

P_N (watts)
3.0

3.6.3 Products tested with an Occupancy Sensor or Touch Technology active in Sleep Mode shall apply the allowances specified in Table 8.

Table 8: Additional Functions Sleep Mode Power Allowance for Signage Displays

Type	Screen Size (in)	Allowance (watts)
Occupancy Sensor P_{OS}	All	0.3
Touch Functionality P_T <i>(applicable only to Signage Displays where screen size is greater than 30 inches)</i>	≤ 30	0.0
	> 30	1.5

3.7 Off Mode Requirements for all Displays

3.7.1 A product need not have an Off Mode to be eligible for certification. For products that do offer Off Mode, measured Off Mode power (P_{OFF}) shall be less than or equal to the Maximum Off Mode Power Requirement (P_{OFF_MAX}) in Table 9.

Table 9: Maximum Off Mode Power Requirement (P_{OFF_MAX})

P_{OFF_MAX} (watts)
0.5

3.8 Luminance and Total Native Resolution Reporting Requirements

- 3.8.1 Maximum Reported, Maximum Measured Luminance, and Total Native Resolution shall be reported for all products; As-Shipped Luminance shall be reported for all products except those with ABC enabled by default.
- a) Testing for the above measurements shall be conducted for the individual Signage Display of a Tiled Display System.

Note: Products intended for sale in the US market are subject to minimum toxicity and recyclability requirements. Please see ENERGY STAR® Program Requirements for Displays: Partner Commitments for details.

4 TEST REQUIREMENTS

4.1 Test Methods

- 4.1.1 Test methods identified in Table 10 shall be used to determine certification for ENERGY STAR.

Table 10: Test Methods for ENERGY STAR Certification

Product Type	Test Method
All Product Types and Screen Sizes	ENERGY STAR Test Method for Determining Display Energy – Rev. April-2019
Enhanced Performance Displays	International Committee for Display Metrology (ICDM) Information Display Measurements Standard – Version 1.03
Displays Claiming Full Network Connectivity	CEA-2037-A, Determination of Television Set Power Consumption
Displays Claiming High Dynamic Range (HDR)	VESA High-performance Monitor and Display Compliance Test Specification (DisplayHDR CTS) Version 1.0

4.2 Number of Units Required for Testing

- 4.2.1 One unit of a Representative Model, as defined in Section 1, shall be selected for testing.
- i. For Tiled Display Systems, the Maximum Tiled Configuration, as defined in Section 1, shall be used for testing.

4.3 International Market Qualification

- 4.3.1 Products shall be tested for qualification at the relevant input voltage/frequency combination for each market in which they will be sold and promoted as ENERGY STAR.

5 USER INTERFACE

- 5.1.1 Manufacturers are encouraged to design products in accordance with the user interface standard, IEEE P1621: Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments. For details, see <http://energy.lbl.gov/controls/>.

6 EFFECTIVE DATE

- 6.1.1 Effective Date: The Version 8 ENERGY STAR Display specification shall take effect on **January 28, 2020**. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on its date of manufacture. The date of manufacture is specific to each unit and is the date on which a unit is considered to be completely assembled.
- 6.1.2 Future Specification Revisions: EPA reserves the right to change this specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through stakeholder discussions. In the event of a specification revision, please note ENERGY STAR certification is not automatically granted for the life of a model.

7 CONSIDERATIONS FOR FUTURE REVISIONS

- 7.1.1 Standby-Active, High Mode: Similar to future revisions of the ENERGY STAR Televisions specification, EPA and the U.S. Department of Energy (DOE) are interested in learning more about Standby-Active, High Mode or Displays with Sleep Modes that demand higher power draw because they are actively running components to reduce latency from Sleep to On Mode, download software updates, or process sensor data. This issue is particularly pertinent with interactive displays that either have a remote or touch screen where the user expects the Display to display content without delay. EPA anticipates exploring this issue and potential power limits and duty cycle requirements in the next specification revision.
- 7.1.2 Revisions to Test Content: As displays technologies continue to evolve, DOE and EPA support external stakeholder efforts to revise test content (i.e. test clips) to better account for how products perform under more realistic consumer viewing conditions, especially with regard to UHD (4K) content and native HDR content.



ENERGY STAR® Program Requirements Product Specification for Displays

**Test Method
Rev. May – 2019**

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Eligibility Criteria for Displays.

2 APPLICABILITY

The following test method is applicable to all products eligible for qualification under the ENERGY STAR Product Specification for Displays.

Note: The U.S. Department of Energy (DOE) has published the Test Procedure for Television Sets Final Rule (78 FR 63823). Any product that is included in DOE's scope of coverage for TVs shall ultimately be tested according to the Test Procedure for Television Sets Rulemaking published by DOE in Appendix H to subpart B of 10 CFR 430.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Eligibility Criteria for Displays.

- A) Host Machine: The machine or device used as the source of video/audio signal for testing Displays. It may be a computer or any other device capable of providing a video signal.
- B) Tiled Display System: A testable configuration of Signage Displays in which multiple Signage Displays are tiled together contiguously and supported by one or more modular external controllers and one or more modular external power supplies to produce a single larger image.
- C) Maximum Tiled Configuration: A Tiled Display System configured with the maximum number of Signage Display panels supported by the same set of external support modules (e.g., power supplies, controllers, etc.) that are needed to support a configuration with two panels. For the purposes of the ENERGY STAR test, the Maximum Tiled Configuration is the primary configuration unless otherwise instructed in the test method.

4 TEST SETUP

- A) Test Setup and Instrumentation: Test setup and instrumentation for all portions of this method shall be in accordance with the requirements of International Electrotechnical Commission (IEC) 62301:2011, "Household electrical appliances - Measurement of standby power," 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.
- B) Ac Input Power: Products capable of being powered from ac mains shall be connected to a voltage source appropriate for the intended market, as specified in Table 1. If an external power supply is shipped with the product, it shall be used to connect the product to the specified voltage source.

Table 1: Input Power Requirements for Products

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

C) Dc Input Power:

- 1) Products may be tested with a dc source (e.g., via network or data connection) only if dc is the only available source of power for the product (i.e., no ac plug or External Power Supply (EPS) is shipped with the product).
- 2) Dc-powered products shall be installed and powered as directed by the manufacturer, using a port with the full specifications recommended for the Display (e.g., Universal Serial Bus (USB) 3.1 if applicable, even if backwards-compatible with USB 2.0).
- 3) The power measurement shall be made between the dc source (e.g., Host Machine) and the cable shipped with the product, including the losses introduced by the shipped cable. If no cable is shipped with the product, any cable between 2 and 6 feet long may be used in its place. The resistance of the cable used to connect the Display to the point of measurement shall be measured and reported.

Note: The measured resistance of dc power cables includes the sum of resistances of both the dc supply voltage wire and the ground wire.

- 4) A spliced cable may be used between the shipped cable and dc source in order to connect the power meter. If this method is used, the following requirements must be met:
 - a) The spliced cable shall be used in addition to the shipped cable described in Section 4.C)3.
 - b) The spliced cable shall be connected between the dc source and the shipped cable.
 - c) The spliced cable shall be no longer than 1 foot.
 - d) For measuring voltage, the total amount of wiring used between the voltage measurement and the shipped cable shall be less than 50 milliohms of resistance. This only applies to the wiring that is carrying load current.

Note: Voltage and current need not necessarily be measured at the same location, so long as the voltage is measured within 50 milliohms of the shipped cable.

- e) The current measurement can be made either on the ground wire or the dc supply voltage wire.
- f) Figure 1 depicts an example spliced cable setup using a USB 2.0-powered Display connected to the Host Machine.

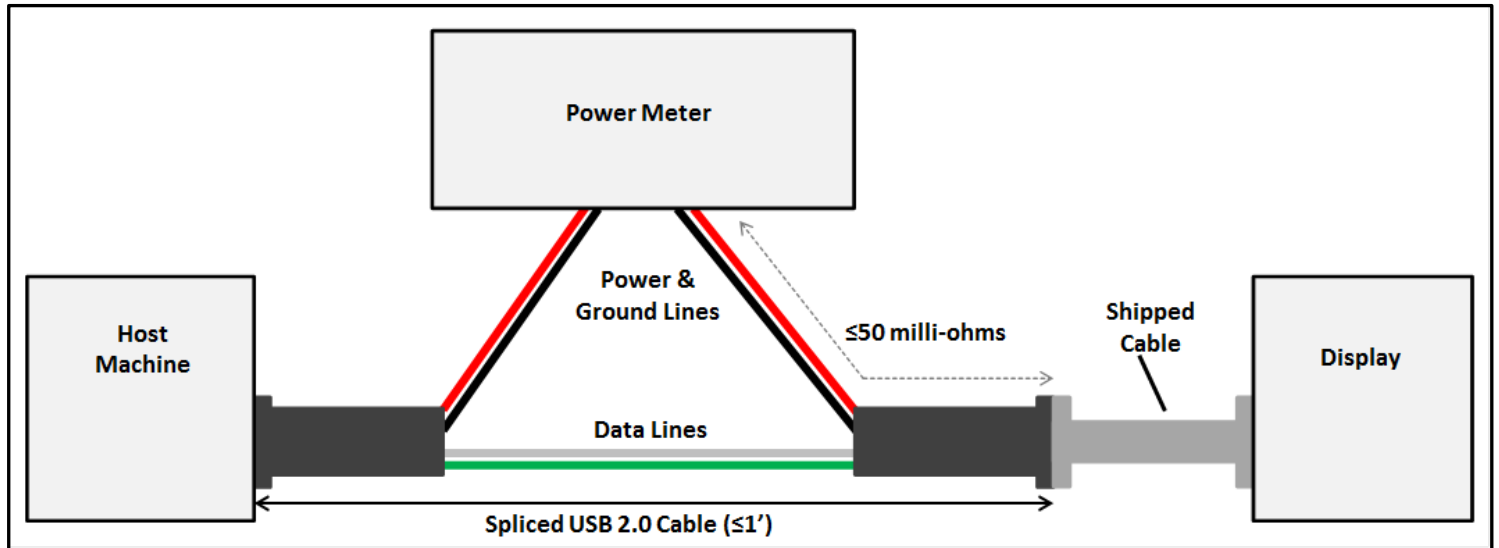


Figure 1: Example Spliced USB 2.0 Cable Arrangement

- D) Ambient Temperature: Ambient temperature shall be $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$.
- E) Relative Humidity: Relative humidity shall be from 10% to 80%.
- F) UUT Alignment:
- 1) All four corners of the face of the Unit Under Test (UUT) shall be equidistant from a vertical reference plane (e.g., wall).
 - 2) The bottom two corners of the face of the UUT shall be equidistant from a horizontal reference plane (e.g., floor).
- G) Light Source for On Mode Testing:
- 1) Lamp Type:
 - a) Standard spectrum halogen flood reflector lamp. The lamp shall not meet the definition of “Modified spectrum” as defined in 10 CFR 430.2 - Definitions¹.
 - b) Rated Brightness: $980 \pm 5\%$ lumens.
 - 2) Light Source Alignment For Testing Products With ABC Enabled By Default:
 - a) There shall be no obstructions between the lamp and the UUT’s Automatic Brightness Control (ABC) sensor (e.g., diffusing media, frosted lamp covers, etc.).
 - b) The center of the lamp shall be placed at a distance of 5 feet from the center of the ABC sensor.
 - c) The center of the lamp shall be aligned at a horizontal angle of 0° with respect to the center of the UUT’s ABC sensor.
 - d) The center of the lamp shall be aligned at a height equal to the center of the UUT’s ABC sensor with respect to the floor (i.e. the light source shall be placed at a vertical angle of 0° with respect to the center of the UUT’s ABC sensor).
 - e) No test room surface (i.e., floor, ceiling, and wall) shall be within 2 feet of the center of the UUT’s ABC Sensor.
 - f) Illuminance values shall be obtained by varying the input voltage of the lamp.
 - g) Figure 2 and Figure 3 and provide more information on UUT and light source alignment.

¹ <http://www.gpo.gov/fdsys/pkg/CFR-2011-title10-vol3/pdf/CFR-2011-title10-vol3-sec430-2.pdf>

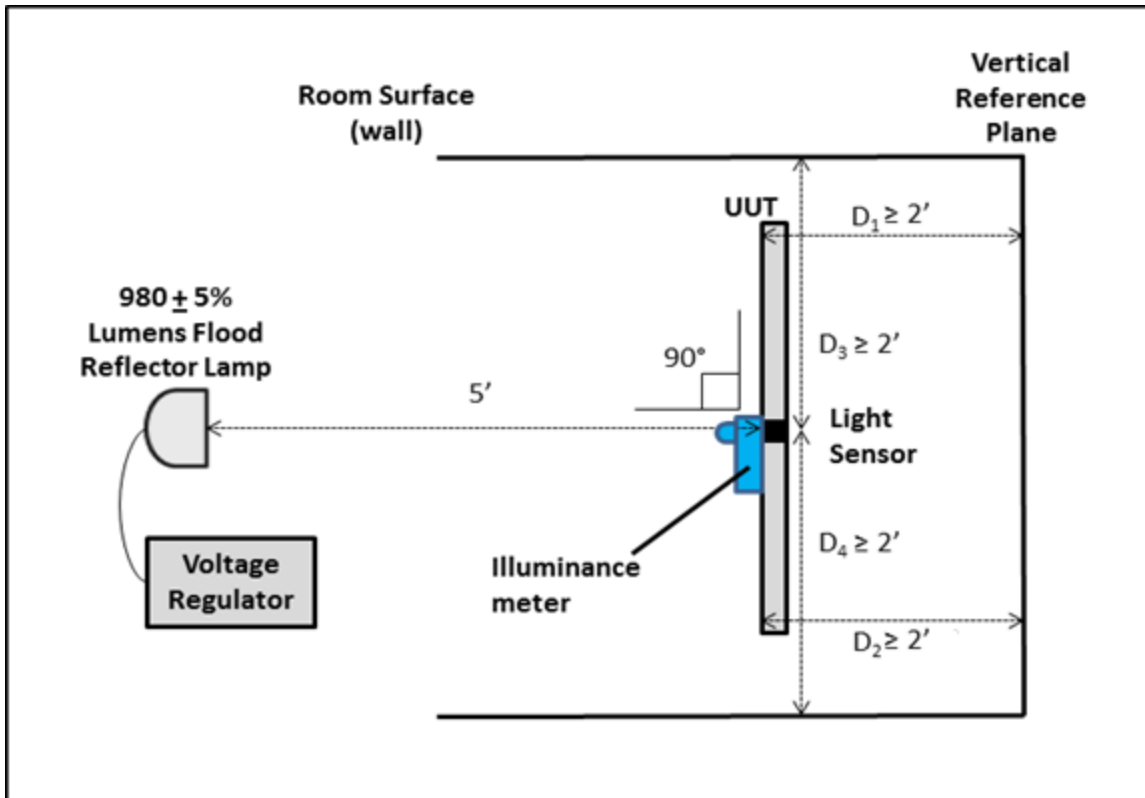


Figure 2: Test Setup - Top View

Notes:

- $D_1 = D_2$ with respect to vertical reference plane
- D_1 and D_2 indicate that the corners of the face of the UUT shall be at least 2 feet from the vertical reference plane
- D_3 and D_4 indicate that the center of the light sensor shall be at least 2 feet from the room walls

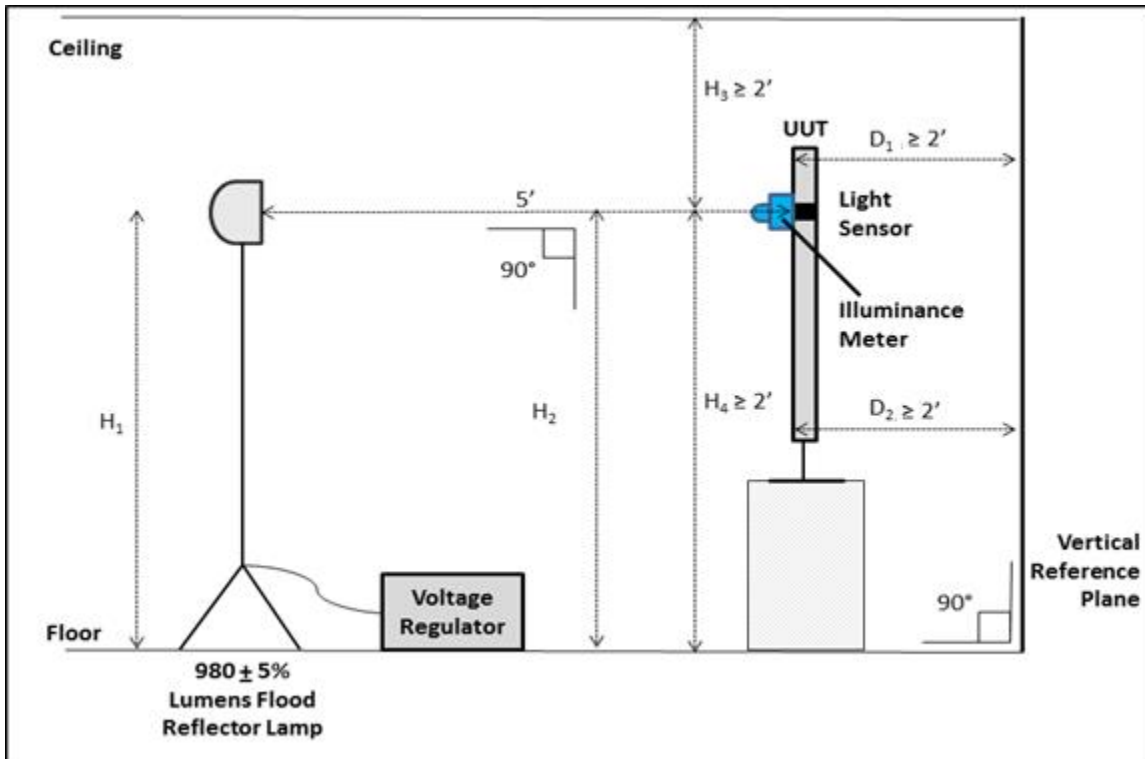


Figure 3: Test Setup - Side View

Notes:

- $D_1 = D_2$ with respect to vertical reference plane
- D_1 and D_2 indicate that the corners of the face of the UUT shall be at least 2 feet from the vertical reference plane
- Illuminance meter shall be removed for power measurements, after target illuminance achieved
- $H_1 = H_2$ with respect to horizontal reference plane (e.g. floor)
- H_3 and H_4 indicate that the center of the light sensor must be at least 2 feet from the floor and 2 feet from the ceiling
- Illuminance meter removed for power measurements, after target illuminance achieved

H) 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) Lower bound on the current range of 10 mA or less.

2) Minimum Frequency Response: 3.0 kHz

3) Minimum Resolution:

- a) 0.01 W for measurement values less than or equal to 10 W;

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

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

I) Luminance and Illuminance Meters:

1) Luminance measurement shall be performed using either

a) A contact meter; or

b) A non-contact meter.

2) All luminance and illuminance meters shall have be accurate to $\pm 2\%$ (± 2 digits) of the digitally displayed value.

3) Non-contact luminance meters shall have an acceptance angle of 3 degrees or less.

Note: The overall accuracy of a meter is found by taking (\pm) the absolute sum of 2% of the measurement and a 2 digit tolerance of the displayed value least significant digit. For example, if an illuminance meter displays "200.0" when measuring a screen brightness of 200 nits, 2% of 200 nits is 4.0 nits. The least significant digit is 0.1 nits. "Two digits" implies 0.2 nits. Thus, the displayed value would be 200 ± 4.2 nits (4 nits + 0.2 nits). The accuracy is specific to the illuminance meter and shall not be considered as tolerance during actual light measurements.

J) Measurement Accuracy:

1) 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.

2) 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.

3) All ambient light values (measured lux) shall be measured at the location of the ABC sensor on the UUT with light entering directly into the sensor and with the main menu from the test signal from IEC 62087:2011, "Methods of measurement for the power consumption of audio, video and related equipment" displayed on the product. For products not compatible with the IEC test signal format, ambient light values shall be measured with the Video Electronics Standard Association (VESA) Flat Panel Display Measurements Standard version 2.0 (FPDM2) FK test signal being displayed on the product.

4) Ambient light values shall be measured within the following tolerances:

a) At 12 lux, ambient lighting shall be within ± 1.0 lux; and

b) At 300 lux, ambient lighting shall be within ± 9.0 lux.

5 TEST CONDUCT

5.1 Guidance for Power Measurements

A) Testing at Factory Default Settings: Power measurements shall be performed with the product in its as-shipped condition for the duration of Sleep Mode and On Mode testing, with all user-configurable options set to factory defaults, except as otherwise specified by this test method.

1) Picture level adjustments shall be performed per the instructions in this test method.

- 2) Except where picture level adjustments are required by the instructions in the test method, products shall be tested in the Default Picture Setting:
 - a) For products that include a Forced Menu that requires picture setting selection upon initial start-up, the Default Picture Setting shall be the “standard” or “home” Preset Picture Setting. In the case that no standard setting or equivalent exists, the default setting recommended by the manufacturer shall be used for testing and recorded in the test report.
 - b) For products that do not include a forced menu, the Default Picture Setting shall be the factory default Preset Picture Setting selected in the as-shipped condition.
- B) Point of Deployment (POD) Modules: Optional POD modules shall not be installed.
- C) Plug-in Modules: Optional Plug-in Modules shall be removed from the Display if the Display can be tested according to the test method without the module installed.
- D) Sleep Mode with Multiple Functionalities: If the product offers multiple options for device behavior in Sleep Mode (e.g., quick start) or multiple methods by which Sleep Mode may be entered, the power during all Sleep Modes shall be measured and recorded. All Sleep Mode testing shall be carried out as per Section 6.5.
- E) Tiled Display Systems: Products that meet the definition of Tiled Displays Systems shall be tested in the Maximum Tiled Configuration which is considered the UUT. The power meter shall be placed between the power source and external power supply supporting the maximum number of panels. In all other respects, Tiled Display Systems shall be tested and shall qualify for ENERGY STAR certification according to the requirements for Signage Displays.

5.2 Conditions for Power Measurements

- A) Power measurements:
 - 1) Power measurements shall be taken from a point between the power source and the UUT. No Uninterruptible Power Supply (UPS) units may be connected between the power meter and the UUT. The power meter shall remain in place until all On Mode, Sleep Mode and Off Mode power data are fully recorded.
 - 2) Power measurements shall be recorded in watts as directly measured (unrounded) values at a rate of greater than or equal to 1 reading per second.
 - 3) Power measurements shall be recorded after voltage measurements are stable to within 1%.
- B) Dark Room Conditions:
 - 1) Unless otherwise specified, the illuminance measured at the UUT screen with the UUT in Off Mode shall be less than or equal to 1.0 lux. If the UUT does not have an Off Mode, the illuminance shall be measured at the UUT screen with the UUT's power cord disconnected.
- C) UUT Configuration and Control:
 - 1) Peripherals and Network Connections:
 - a) External peripheral devices (e.g. mouse, keyboard, external hard disk drive (HDD), speakers etc.) shall not be connected to USB ports or other data ports on the UUT.
 - b) Bridging: If the UUT supports bridging per the definition in Section 1 of the ENERGY STAR Eligibility Criteria for Displays Version 8.0, a bridge connection shall be made between the UUT and the Host Machine. The connection shall be made in the following order of preference. Only one connection shall be made and the connection shall be maintained for the duration of the test.
 - i. Thunderbolt
 - ii. USB

- iii. Firewire (IEEE 1394)
- iv. Other

Note: Examples of bridging for Displays may include:

1. *A case where the Display converts data between two different port types (e.g. Thunderbolt and Ethernet). This can allow a device to use Thunderbolt as an Ethernet connection or vice versa.*
 2. *Allowing a USB keyboard/mouse to be connected to another system (e.g. Host Machine) through the Display by a USB hub controller.*
- c) Networking: If the UUT has networking capability (i.e., it has the ability to obtain an IP address when configured and connected to a network) the networking capability shall be activated, and the UUT shall be connected to a live physical network (e.g., Wi-Fi, Ethernet, etc.). The physical network shall support the highest and lowest data speeds of the UUT's network function. An active connection is defined as a live physical connection over the physical layer of the networking protocol. In the case of Ethernet, the connection shall be via a standard Cat 5e or better Ethernet cable to an Ethernet switch or router. In the case of Wi-Fi the device shall be connected and tested in proximity to a wireless access point (AP). The tester shall configure the address layer of the protocol, taking note of the following:
- i. Internet Protocol (IP) v4 and IPv6 have neighbor discovery and will generally configure a limited, non-routable connection automatically.
 - ii. IP can be configured manually or by using Dynamic Host Configuration Protocol (DHCP) with an address in the 192.168.1.x Network Address Translation (NAT) address space if the UUT does not behave normally when autoIP is used. The network shall be configured to support the NAT address space and/or autoIP.
 - iii. The UUT shall maintain this live connection to the network for the duration of testing unless otherwise specified in this Test Method, disregarding any brief lapses (e.g., when transitioning between link speeds). If the UUT is equipped with multiple network capabilities, only one connection shall be made in the following order of preference:
 - a. Wi-Fi (Institution of Electrical and Electronics Engineers - IEEE 802.11- 2007²)
 - b. Ethernet (IEEE 802.3). If the UUT supports Energy Efficient Ethernet (IEEE 802.3az-2010³), then it shall be connected to a device that also supports IEEE 802.3az
 - c. Thunderbolt
 - d. USB
 - e. Firewire (IEEE 1394)
 - f. Other
- d) Touchscreen Functionality: If the UUT features a touchscreen that requires a separate data connection, this function shall be set up as directed by the manufacturer's instructions, including connections to the Host Machine and installation of software drivers.
- e) In the case of a UUT that has a single connection capable of performing multiple functions (e.g. bridging, networking, and/or touchscreen functionality), a single connector can be used to meet these functionalities provided it is the highest preferred connection the UUT supports

² IEEE 802 – Telecommunications and information exchange between systems—Local and metropolitan area networks – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

³ Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Amendment 5: Media Access Control Parameters, Physical Layers, and Management Parameters for Energy-Efficient Ethernet

- for each functionality.
- f) In the case of a UUT that has no data/network capabilities, the UUT shall be tested as-shipped.
 - g) Built-in speakers and other product features and functions not specifically addressed by the ENERGY STAR eligibility criteria or test method must be configured in the as-shipped power configuration.
 - h) Availability of other capabilities such as occupancy sensors, flash memory-card/smart-card readers, camera interfaces, PictBridge shall be recorded.
- 2) Signal Interface:
- a) If the UUT has multiple signal interfaces, the UUT shall be tested with the first available interface from the list below:
 - i. Thunderbolt
 - ii. DisplayPort
 - iii. USB-C
 - iv. HDMI
 - v. DVI
 - vi. VGA
 - vii. Other Digital Interface
 - viii. Other Analog Interface
- 3) Occupancy Sensor: If the UUT has an occupancy sensor, the UUT shall be tested with the occupancy sensor settings in the as-shipped condition. For UUT's with an occupancy sensor enabled as-shipped:
- a) A person shall be within close proximity of the occupancy sensor for the entire warm up, stabilization, luminance testing and On Mode to prevent the UUT from entering a lower power state (e.g. Sleep Mode or Off Mode). The UUT shall remain in On Mode for the duration of the warm up period, stabilization period, luminance test and On Mode test.
 - b) No person shall be within close proximity of the occupancy sensor for the duration of the Sleep Mode and Off Mode tests to prevent the UUT from entering a higher power state (e.g. On Mode). The UUT shall remain in Sleep Mode or Off Mode for the duration of the Sleep Mode or Off Mode tests, respectively.
- 4) Orientation: If the UUT can be rotated into vertical and horizontal orientations, it shall be tested in the horizontal orientation, with the longest dimension being parallel to the table surface.
- D) Resolution and Refresh Rate:
- 1) Fixed-pixel Displays:
 - a) Pixel format shall be set to the native level as specified in the product manual.
 - b) For non-Cathode Ray Tube (CRT) Displays, refresh rate shall be set to 60 Hz, unless a different default refresh rate is specified in the product manual, in which case the specified default refresh rate shall be used.
 - c) For CRT Displays, pixel format shall be set to the highest resolution that is designed to be driven at a 75 Hz refresh rate, as specified in the product manual. Typical industry standards for pixel format timing shall be used for testing. Refresh rate shall be set to 75 Hz.
- E) Accuracy of Input Signal Levels: When using analog interfaces, video inputs shall be within $\pm 2\%$ of referenced white and black levels. When using digital interfaces, the source video signal shall not be adjusted for color, or modified by the tester for any purpose other than to compress/inflate and

encode/decode for transmission, as required.

- F) True Power Factor: Partners shall report the true power factor (PF) of the UUT during On Mode measurement. The power factor values shall be recorded at the same rate at which the power value (P_{ON}) are recorded. The reported power factor shall be averaged over the entire duration of the On Mode testing.
- G) Test Materials:
- 1) "IEC 62087:2011 Dynamic Broadcast-Content Signal" shall be used for testing, as specified in IEC 62087:2011, Section 11.6, "On (average) mode testing using dynamic broadcast-content video signal."
 - 2) "VESA FPDM2" shall be used only for products that cannot display the IEC 62087:2011 Dynamic Broadcast-Content Signal.
- H) Host Machine and Video Input Signal:
- 1) The Host Machine shall generate the video input signal in the native resolution of the Display such that the active area of the video fills the entire screen. This may require the playback software to adjust the aspect ratio of the video.
 - 2) The frame rate of the video input signal should match the frame rate most commonly used in the region in which the product is sold (e.g., For the US and Japan a 60 Hz frame rate is used; for Europe and Australia a 50 Hz frame rate is used).
 - 3) The audio settings on the Host Machine shall be disabled so that no sound is produced alongside the video input signal.
 - 4) The Host Machine shall not have a battery and must operate on its own ac power source (e.g. desktop computer, Blu-ray player, etc.). If a UUT must be used with a Host Machine that requires a battery, ensure that the battery is fully charged and the Host Machine is connected to an ac power source prior to connecting to the UUT.

6 TEST PROCEDURES FOR ALL PRODUCTS

6.1 Pre-Test UUT Initialization

- A) Prior to the start of testing, the UUT shall be initialized as follows:
- 1) Set up the UUT per the instructions in the supplied product manual.
 - 2) Connect an acceptable watt meter to the power source and connect the UUT to the power outlet on the watt meter.
 - 3) With the UUT off, set the ambient light level such that the measured screen illuminance is less than 1.0 lux (see Section 5.2B)).
 - 4) Power on the UUT and perform initial system configuration, as applicable.
 - 5) Ensure UUT settings are in their as-shipped configuration, unless otherwise specified in this test method.
 - 6) Warm up the UUT for 20 minutes, or the time it takes the UUT to complete initialization and become ready for use, whichever is longer. The IEC 62087:2011 test signal format, as specified in Section 5.2G)1), shall be displayed for the entire warm up period. Displays that cannot display the IEC 62087:2011 test signal format shall have the VESA FPDM2 L80 test signal, as specified in Section 5.2G)2), displayed on the screen.
 - 7) Report the ac input voltage and frequency or dc input voltage.
 - 8) Report the test room ambient temperature and relative humidity.

6.2 Luminance Testing

- A) Luminance testing shall be performed immediately following the warm up period and in dark room conditions. Product screen illuminance, as measured with the UUT in Off Mode, shall be less than or equal to 1.0 lux.
- B) Luminance shall be measured perpendicular to the center of the product screen using a luminance meter in accordance with the meter's user manual.
- C) The position of the luminance meter relative to the product screen shall remain fixed throughout the duration of testing.
- D) For products with ABC, luminance measurements shall be performed with ABC disabled. If ABC cannot be disabled, luminance measurements shall be measured perpendicular to the center of the product screen with light entering directly into the UUT's ambient light sensor at greater than or equal to 300 lux.
- E) For Tiled Display Systems, luminance measurements shall be performed individually for each Signage Display module in the Maximum Tiled Configuration. All luminance values reported shall be calculated as the average luminance of all modules in the Maximum Tiled Configuration. The measured luminance shall only include light from the individual display, and not the other displays.
- F) Luminance measurements shall be performed as follows:
 - 1) Verify that the luminance of the UUT is set according to the Default Picture Setting identified in 5.1 A) 2).
 - 2) Display the test video signal for the specific product class, as described below:
 - a) **All products, except as specified in b):** Three-bar video signal specified in IEC 62087:2011, Section 11.5.5 (three bars of white (100%) over a black (0%) background).
 - b) **Products that cannot display signals from IEC 62087:2011:** VESA FPDM2 L80 test signal for the maximum resolution supported by the product.
 - 3) Display the test video signal for no less than 10 minutes to allow the UUT luminance to stabilize. This 10 minute stabilization period may be reduced if luminance measurements are stable to within 2% over a period of not less than 60 seconds.
 - 4) Measure and record the luminance in default as-shipped setting $L_{As-shipped}$.
 - 5) Set the brightness and contrast levels of the UUT to their maximum values.
 - 6) Measure and record the luminance as $L_{Max_Measured}$.
 - 7) Record the manufacturer-reported maximum luminance $L_{Max_Reported}$.
- G) The contrast setting shall be left at the maximum level for the subsequent On Mode tests unless otherwise specified.

6.3 On Mode Testing for Products without ABC Enabled by Default

- A) After the Luminance Testing and prior to On Mode power measurement, the luminance of the UUT shall be set according to the following:
 - 1) **For Signage Displays (including Tiled Display Systems)**, the product, which includes all modules in the Maximum Tiled Configuration for Tiled Display Systems, shall be tested with luminance set at a value greater than or equal to 65% of the manufacturer-reported maximum luminance ($L_{Max_Reported}$). Luminance values shall be measured for each module individually as per Section 6.2. This luminance value L_{On} , which for Tiled Display Systems should be computed as the average of all modules in the Maximum Tiled Configuration, shall be recorded.
 - 2) **For all other products**, adjust appropriate luminance controls until the luminance of the screen is **200 candelas per square meter (cd/m^2)**. If the UUT cannot achieve this luminance, set the product luminance to the nearest achievable value. Luminance values shall be measured as per Section 6.2. This luminance value L_{On} shall be reported. Appropriate luminance controls refer to any controls that adjust the brightness of the Display, but do not include contrast settings.

- 3) The luminance, as measured per Section 6.2 but without the 10 minute stabilization period, shall meet the requirements above at any point during the On Mode test.
- B) For a UUT capable of displaying the IEC signals, On Mode power (P_{ON}) shall be measured according to IEC 62087:2011 Section 11.6.1 “Measurements using dynamic broadcast-content video signal.” For a UUT not capable of displaying the IEC signals, On Mode power (P_{ON}) shall be measured as follows:
- 1) Ensure that the UUT has been initialized per Section 6.1.
 - 2) Display the VESA FPDM2, A112-2F, SET01K test pattern (8 shades of gray from full black (0 volts) to full white (0.7 volts)).
 - 3) Verify that input signal levels conform to VESA Video Signal Standard (VSIS), Version 1.0, Rev. 2.0, December 2002.
 - 4) With the brightness and contrast controls at maximum, verify that the white and near-white grey levels can be distinguished. If necessary, adjust contrast controls until the white and near-white grey levels can be distinguished.
 - 5) Display the VESA FPDM2, A112-2H, L80 test pattern (full white (0.7 volts) box that occupies 80% of the image).
 - 6) Ensure that the luminance measurement area falls entirely within the white portion of the test pattern.
 - 7) Adjust appropriate luminance controls until the luminance of the white area of the screen is set as described in Section 6.3A).
 - 8) Record the screen luminance (L_{ON}).
 - 9) Record On Mode power (P_{ON}) and total pixel format (horizontal x vertical). The On Mode power shall be measured over a 10 minute period similar to the IEC 62087:2011 dynamic broadcast-content test.
 - 10) If the Host Machine draws power from the UUT then the power drawn shall be included in the On Mode power measurement.

6.4 On Mode Testing for Products with ABC Enabled by Default

The average On Mode power consumption of the product shall be determined with the dynamic broadcast-content as defined in IEC 62087:2011. If the product cannot display the IEC signal, then the VESA FPDM2 L80 test pattern, as described in Section 6.3A)5), shall be used for all of the following steps.

- A) Stabilize the UUT for 30 minutes. This shall be done with three repetitions of the 10 minute IEC dynamic broadcast-content video signal.
- B) Set the light output of the lamp used for testing to 12 lux as measured at the face of the ambient light sensor.
- C) Display the 10 minute dynamic broadcast-content video signal. Measure and record the power consumption, P_{12} , during the 10 minute dynamic broadcast-content video signal.
- D) Repeat steps 6.4B) and 6.4C) for an ambient light level of 300 lux, to measure P_{300} .
- E) Disable ABC and measure On Mode power (P_{ON}) per Section 6.3. If ABC cannot be disabled, power measurements shall be conducted as follows:
 - 1) If the brightness can be set to a fixed value as specified in Section 6.3, then On Mode power for these products shall be measured as per Section 6.3 with light entering directly into the UUT’s ambient light sensor at greater than or equal to 300 lux.
 - 2) If the brightness cannot be set to a fixed value, then On Mode power for these products shall be measured as per Section 6.3 with light entering directly into the UUT’s ambient light sensor at greater than or equal to 300 lux and without modifying the screen brightness.

6.5 Sleep Mode Testing

- A) Sleep Mode power (P_{SLEEP}) shall be measured according to IEC 62301:2011, with the additional guidance in Section 5.
- B) The Sleep Mode test shall be conducted with the UUT connected to the Host Machine in the same manner as in the On Mode test. If possible, Sleep Mode shall be enacted by putting the Host Machine to sleep. For a computer Host Machine, Sleep Mode is defined in the Version 7.1 ENERGY STAR Computers specification.
- C) If the product has a variety of Sleep Modes that may be manually selected, or if the product can enter Sleep Mode via different methods (e.g., remote control or putting the Host Machine to sleep), measurements shall be performed and recorded in all Sleep Modes.

If the product automatically transitions through its various Sleep Modes, the measurement time shall be long enough to obtain an average of all Sleep Modes. The measurement shall still meet requirements (e.g., stability, measurement period, etc.) outlined in Section 5.3 of IEC 62301:2011.

6.6 Off Mode Testing

- A) For products having Off Mode capability, at the conclusion of the Sleep Mode test, initiate Off Mode via the most easily accessible power switch.
- B) Measure Off Mode power (P_{OFF}) according to Section 5.3.1 of the IEC 62301:2011. Document the method of adjustment and sequence of events required to reach Off Mode.
- C) Any input synchronizing signal check cycle may be ignored when measuring Off Mode power.

6.7 Luminance Testing for Products Claiming HDR Capability

- A) Products claiming HDR capability shall be tested according to the VESA High-performance Monitor and Display Compliance Test Specification (DisplayHDR CTS) Version 1.0, Section 5.1: Minimum-white Luminance Level Specifications. The maximum DisplayHDR performance tier for which the UUT meets all three Minimum-white Luminance requirements shall be reported. Products previously certified to VESA DisplayHDR standards may be exempted from testing, in which case the certified DisplayHDR performance tier shall be reported.

6.8 Additional Testing

- A) For products with data/networking capabilities or a bridge connection, in addition to tests performed with data/networking capabilities activated and a bridge connection established (see Section 5.2C)1)), Sleep Mode Testing shall be performed with data/networking features deactivated and without any bridge connection established.
- B) The presence of Full Network Connectivity shall be determined by testing the Display for network activity in Sleep Mode according to section 6.7.5.2 of CEA-2037-A, Determination of Television Set Power Consumption, with the following guidance:
 - 1) The Display shall be connected to a network per Section 5.2C)1)c) prior to the test.
 - 2) The Display shall be placed into Sleep Mode in place of standby-active, low mode.