ENERGY STAR® Program Requirements for Electric Vehicle Supply Equipment

Test Method for DC EVSE
Draft 2

1 OVERVIEW

The following test method shall be used for determining DC EVSE compliance with requirements in the ENERGY STAR Eligibility Criteria for Electric Vehicle Supply Equipment.

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 test procedures in Sections 7.1, 7.2, 7.3, and 7.4 shall be performed on all products.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Eligibility Criteria for Electric Vehicle Supply Equipment, Version 1.0. Presented below are new definitions specific to DC EVSE.

Note: The below section lists the definitions that EPA is considering using throughout the EVSE program, in addition to those terms already defined in the Version 1.0 EVSE specification. This section will eventually be moved to the Version 1.1 Specification/Eligibility Criteria document but is included temporarily in this draft Test Method for ease of reference and to ensure that all aspects of the test method are defined appropriately.

A) Electric Vehicle Supply Equipment (EVSE): The conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatuses installed specifically for the purpose of delivering energy to the electric vehicle. Charging cords with NEMA 5 15P and NEMA 5-20P attachment plugs are considered EVSEs. Excludes conductors, connectors, and fittings that are part of the vehicle.

Note: One stakeholder noted that the definition of EVSE may limit the scope to exclude products that do not require connection to premises wiring and do not draw energy from conventional AC or DC wiring (e.g., off-grid solar PV EVSE systems do not draw energy from an external source). EPA has removed the term 'premises wiring' from the EVSE definition to account for systems like off-grid PV-supplied EVSE.

1) Level 1: A galvanically-connected EVSE with a single-phase input voltage nominally 120 volts ac and maximum output current less than or equal to 16 amperes ac.

2) Level 2: A galvanically-connected EVSE with a single-phase input voltage range from 208 to 240 volts ac and maximum output current less than or equal to 80 amperes ac.

3) DC: A method that uses dedicated direct current (DC) electric vehicle/plug-in hybrid electric vehicle (EV/PHEV) supply equipment to provide energy from an appropriate off-board charger to the EV/PHEV in either private or public locations.[1]

4) Wireless / Inductive: A non-galvanically-connected EVSE.

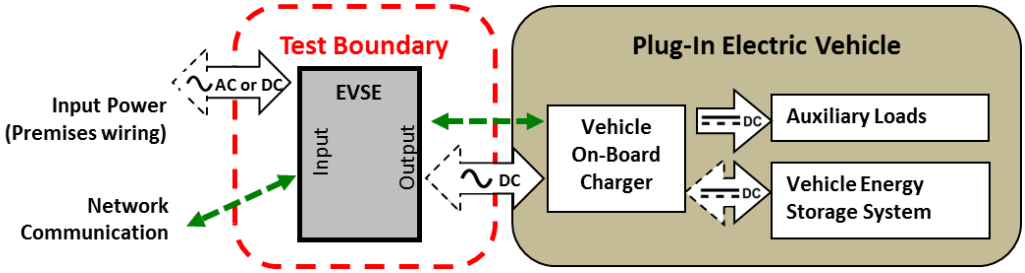


Figure 1: Schematic of Overall Plug-In Vehicle Charging System detailing DC-Output EVSE Test Boundary

B) Cabinet/Dispenser Product Configuration – A DC EVSE that has its components in two separate enclosures – one including the power conversion equipment (i.e., cabinet) and another enclosure that connects to the vehicle and has the user interface (i.e., dispenser).

C) All-in-One Product Configuration – A DC EVSE that has all of its components in one enclosure.

4 SCOPE

Note: The below section lists the intended scope that EPA is considering using in the Version 1.1 EVSE specification, in addition to the products already included in the Version 1.0 EVSE specification. This section will eventually be moved to the Version 1.1 Specification/Eligibility Criteria document but is included temporarily in this draft Test Method for ease of reference.

Given the nascent state of the market for larger DC-output EVSE, EPA is proposing to include equipment with output power less than or equal to 350 kW, which includes the majority of products available today. In the specification, EPA proposes to separate DC-output EVSE into three bins, based on maximum output power, to set criteria as shown here:

DC EVSE Output Power	≤ 50 kW	50 kW < Output Power ≤ 350 kW	> 350 kW
Standby Mode Criteria	✓	✓	Out of scope, no criteria
Operation Mode Criteria	✓	Report efficiency, but no criteria	
Network Connection Required	✓	✓	

In this Draft 2, EPA is proposing new requirements to allow for the testing of DC-input EVSE, such as those intended to be used with solar photovoltaic (PV) systems.

[1] SAE International, Surface Vehicle Standard J1772, "SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler", Oct. 2017, Section 3.10.

EPA also proposes to exclude pantograph EVSE (chargers with an automated connection system, or ACS) from the scope of the Version 1.1 since standard operating parameters for these product types are still under development. EPA would appreciate stakeholder feedback on this proposal.

4.1 Included Products

4.1.1 DC-output EVSE with output power less than or equal to 350 kW.

4.2 Excluded Products

4.2.1 DC-output EVSE with output power greater than 350 kW.

5 TEST SETUP

A) Test Setup and Instrumentation: Test setup shall be in accordance with the diagram in Figure 1a with additional requirements specified below. For EVSE that have a Cabinet/Dispenser product configuration, connect the two enclosures with the shortest cable possible.

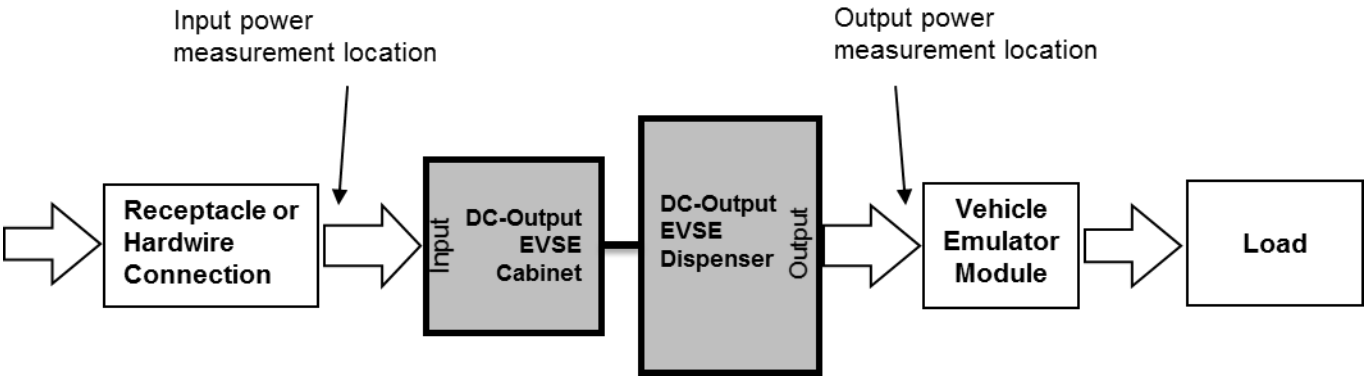


Figure 1a: Schematic of test setup connection for a cabinet/Dispenser Product Configuration. The two components are in one enclosure in an All-in-One Product Configuration

B) AC-input Power: The UUT shall be operated at the first (highest) rated voltage and rated frequency combination specified in Table 1.

1) If the UUT requires two different voltages simultaneously (e.g., a lower voltage for accessory loads), then the requirements in this section shall apply to each voltage connection separately—i.e., first connect the high-voltage connection, then the low-voltage connection.
2) UUTs that are not compatible with any of the combinations listed in Table 1 shall be connected to the highest rated voltage and frequency combination appropriate for the intended market. The voltage and frequency used for the test shall be reported.
3) The voltage and frequency tolerance shall be as specified in Table 2.
4) Testing shall exclude any external transformer.
5) EVSE that support both 3-phase and single-phase input power shall be tested using 3-phase power (indicated with a Δ symbol for delta-connected three-phase, and Y for wye-connected three-phase).

Table 1: AC-input Supply Requirements

Voltage and Precedence	Frequency
1. 600Δ V ac	60 Hz
2. 600Y/346 V ac	60 Hz
3. 480Δ V ac	60 Hz
4. 480Y/277 V ac	60 Hz
5. 415Δ V ac	60 Hz
6. 415Y/240 V ac	60 Hz
7. 400Δ V ac	50 Hz
8. 400Y/230 V ac	50 Hz
9. 240 V AC	60 Hz
10. 208 V AC	60 Hz
11. 120 V AC	60 Hz

Table 2: AC-input Power Tolerances

Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency Tolerance
+/- 4.0 %	5.0 %	+/- 1.0 %

C) DC-input Power: The UUT shall be tested at the nameplate rated voltage.

1) The voltage and frequency used for the test shall be reported.
2) The voltage tolerance shall be as specified in Table 3.
3) Products that require both DC and AC-input power shall be connected to both applicable input power sources, and both types of input power shall be measured and summed.
4) Products that can accommodate either DC or AC-input power shall be tested with AC-input power and again with DC-input power.

Table 3: DC-input Power Tolerances

Voltage Tolerance
+/- 4.0 %

Note: A stakeholder noted that off-grid EVSE need to be tested with an actual solar array or other DC source (e.g., a DC power supply) but if another DC source is used, careful consideration will need to be made on how to simulate the output of a PV panel array, including I-V characteristics. A solar array's output has a region of constant current at low voltages followed by a knee in the curve where output power is at a maximum, leading to a decline in current as voltage approaches the open-circuit voltage. They noted that at a minimum, the test method should specify the highest DC-input voltage and the maximum current, consistent with the manufacturers recommendations in order to protect the EVSE from damage.

Another stakeholder noted that it is not practical to ship and setup large numbers of solar panels as a DC source for off-grid DC EVSE systems.

EPA received feedback that if a predefined DC-input voltage is specified, it may not represent the overall product efficiency because DC-input power can come from a variety of sources, including PV or batteries. As a result, EPA believes that testing at the nameplate input voltage for products with DC-input may be the most suitable to measure efficiency for DC EVSE intended to operate with varying supply sources.

In addition, EPA has provided for the possibility of DC-output EVSE that take both DC and AC-input voltage.

D) Input Power Measurements:

1) Cables: All power cables for the test shall be the default provided by the manufacturer

2) For EVSE equipped with input plug(s) and cord(s), the corresponding receptacle shall be used to provide power to the input plug(s) of the EVSE. If this is an EVSE with multiple inputs at the same voltage, the inputs shall be connected together in parallel, requiring only one power supply and one power meter. An Input Measurement Apparatus (IMA) shall be used with EVSE that are provided with input plug(s) and cord(s). The IMA enables input current and input voltage measurements of the EVSE without the need to modify the EVSE input cord(s).

   a) Voltage Measurements shall be performed at the wiring terminals of the receptacle in the IMA providing power to the EVSE input plug.

   b) Current Measurements shall be performed on the wiring of the IMA connected to receptacle terminals.

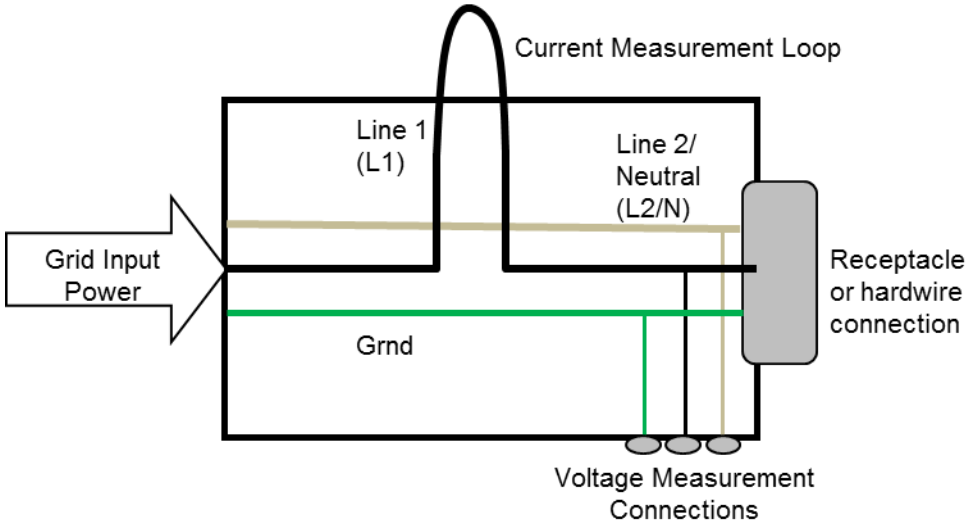


Figure 2: Schematic of Input Measurement Apparatus (IMA)[2]

3) For EVSE intended for hardwire connection, the UUT's input power shall then be connected to AC-input Power source with cables and optional connectors that are rated for the voltage and current levels that will be encountered during testing.

   a) Voltage Measurements shall be performed at the hardwire connection location at the input terminal of the EVSE.

   b) Current Measurements shall be performed on the wiring to the EVSE hardwire connection.

E) Ambient Temperature: Ambient temperature shall be set at the conditions specified in Table 3 for EVSE without active cooling or heating, and Table 4 for EVSE with active cooling or heating for all portions of the test.

   a) Once the temperatures in Table 5 and Table 6 have been attained, the UUT shall remain in the test chamber at the specified temperature for 2 hours prior to power testing.

   b) UUTs with active cooling or heating shall be tested at all three ambient temperatures in Table 6 during Operation Mode testing. For No Vehicle Mode, Partial On Mode, and Idle Mode testing, the UUT shall be tested only at the temperate condition.

Table 3: Ambient Test Temperature for DC EVSE without Active Cooling or Heating

Type of Climate	Representative Temperature	Applicable Test
Temperate	68° F or 20° C (± 5° F, ± 2.5° C)	No Vehicle Mode, Partial On Mode, Idle Mode, and Operation Mode

Table 4: Ambient Test Temperatures for DC EVSE with Active Cooling or Heating

Type of Climate	Representative Temperature	Applicable Test
Cold	20° F or –7° C (± 5° F, ± 2.5° C)	Operation Mode
Temperate	68° F or 20° C (± 5° F, ± 2.5° C)	No Vehicle Mode, Partial On Mode, Idle Mode, and Operation Mode
Hot	104° F or 40° C (± 5° F, ± 2.5° C)	Operation Mode

Note: Based on discussions with manufacturers, EPA does not expect much variation in energy use for standby modes due to ambient temperature. As a result, EPA is proposing that EVSE with active cooling or heating be tested in all three temperature conditions for Operation Mode but only in the temperate temperature condition (68° F or 20° C) for the three standby modes. EPA would appreciate stakeholder feedback on this proposal.

[2] In a four-conductor system, the conductor labeled L2/N will actually be two separate conductors: L2 and N.

In addition, one stakeholder noted that if an EVSE is passively cooled (i.e., no fans, liquid-filled cables, etc.) then the impact of ambient temperature will be small, so they recommended testing these products at one temperature to reduce unnecessary test burden. EPA appreciates this feedback and agrees that if products are passively-cooled, and do not have cooling systems that require additional power, they do not need to be tested in three different temperature conditions. As a result, EPA has included guidance in the test method that requires passively-cooled EVSE to be tested in the temperate temperature condition only (68° F or 20° C).

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

G) Test Load: A DC Test Load shall be used for testing DC-output EVSE. The DC load shall be combined with a Vehicle Emulator Module (VEM) that can communicate via the protocol defined for the connector type intended to ship with the product (e.g., for Combined Charging System, or CCS, the VEM may communicate via SAE J1772 Appendix F and G along with other protocols).

Note: A stakeholder noted that communication between the EV and EVSE for CCS connectors will take place on the SAE J1772 control pilot but should include both the J1772 PWM signaling protocol and the IEC/ISO 15118 or DIN 70121 digital communications protocol because a DC EVSE may require digital communications for normal operation. They stated that this should be considered for the modal test procedures because those sections don't consider digital communications between the EV and EVSE.

EPA agrees with this stakeholder that different communication protocols may be used for communication between the EV and EVSE. As a result, the Draft 2 Test Method clarifies that the reference to the SAE J1772 control pilot is just one example of how communication can take place for a CCS connection. EPA acknowledges that communication protocols will differ depending on the connecter type and that several protocols may be necessary for communication between the EVSE and technician.

1) Load: The load shall possess the following capabilities:

   a) Sink current up to the rated current of the UUT;

   b) Voltage of 350 V; for UUTs that are not compatible with 350 V, the voltage shall be the highest compatible with the output requirements of the UUT; and

   c) Controllable current levels capable of achieving power levels detailed in Table 5 for AC-input or Table 6 for DC-input.

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

1) Number of Channels: The number of channels sufficient to measure all input current into the device shall be set up.

2) Crest Factor (applicable to AC-input only):

   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.

3) Minimum Frequency Response (applicable to AC-input only): 3.0 kHz

Note: A stakeholder noted that crest factor is a measurement of peak value of an AC waveform to the RMS value and this would not be relevant for testing DC-input EVSE, and neither would frequency response. EPA has clarified that these requirements apply to AC-input EVSE testing only.

4) Minimum Resolution:

   a) 0.1 W for measurement values less than 100 W; and

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

5) Accuracy: +/- 0.1% of reading PLUS +/- 0.1% of full scale

Note: This requirement pertains to the accuracy of the power meter only. For the accuracy of the entire measurement system, see Section 6.1.H). For more information, see ISO/IEC 98-3:2008 Guide to Expression of Uncertainty in Measurement.

Note: A stakeholder suggested that EPA add explanations with the measurement accuracy for all products requirements in Section 5.1 H)1) to describe how inaccuracy would be measured. EPA has included a reference to a guide for determining uncertainty in testing (ISO/IEC 98-3:2008 Guide to Expression of Uncertainty in Measurement) so laboratories will be able to better estimate sources of uncertainty.

6) Measurements and Calculations:

a) Cable Length (ft.);

b) Cable Gauge (AWG);

c) Average Power (W); and

d) AC-input EVSE only:

i. Power Factor (PF) ;

ii. Apparent Power (S);

iii. Voltage (RMS);

iv. Current (RMS);

v. Frequency (Hz).

Note: A stakeholder noted that power factor, apparent power, and RMS measurements are not applicable for DC-input EVSE. They requested that EPA include measurements for DC power sources as well. EPA has clarified that these measurements are only applicable to AC-input EVSE.

I) Illuminance Meter Accuracy:

1) All illuminance meters shall be accurate to ± 2% (± 2 digits) of the digitally displayed value.

Note: The overall accuracy of a meter is found by taking (±) the absolute sum of 2% of the measurement and a 2-digit tolerance of the displayed value least significant digit. For example, if a meter displays “200.0” when measuring an illuminance of 200 lx, 2% of 200 lx is 4.0 lx. The least significant digit is 0.1 lx. “Two digits” implies 0.2 lx. Thus, the displayed value would be 200 ± 4.2 lx (4 lx + 0.2 lx). The accuracy is specific to the illuminance meter and shall not be considered as tolerance during actual light measurements. Light measurements shall be within the tolerance specified in 6.1.E)3).

6 TEST CONDUCT

6.1 Guidance for Implementation of the EVSE Test Procedure

A) As-shipped Condition: Unless specified otherwise, the model unit shall be tested in its default configuration as-shipped.

1) If no default settings are available and unless specified otherwise, the tester shall follow manufacturer recommendations regarding UUT set-up, or if no manufacturer recommendations are available, the first available setting.

Note: A stakeholder suggested a few changes to the requirement that the EVSE be configured as-shipped because they are typically configured in the field. They recommended that EPA:

• Require screens display a typical greeting message

• Require that other settings are configured according to manufacturer recommendations

The Draft 1 Test Method specified that the settings are in their as-shipped configuration. The Draft 2 supplements this guidance noting that manufacturer recommendations be used to configure any DC EVSE that offers customizable settings rather than a default configuration.

2) The UUT shall be installed per the manufacturer's installation instructions. If no manufacturer instructions are provided, the UUT shall be tested on a thermally non-conductive surface (e.g., wood or rubber).

B) UUT Configuration and Control:

1) Network Connection Capabilities:

a) Verify the UUT has network connection capabilities:

i. Network connections should be listed in the user manual or installation instructions.

ii. If no connections are specified, verify that the EVSE does not have network capabilities by checking for the absence of physical connections or the absence of network settings in the menu.

2) Peripherals and Network Connections:

b) Any peripherals shipped with the UUT shall be connected to their respective ports per manufacturer instructions. No other devices or accessories shall be connected to any remaining open ports.

c) If the UUT has network connection capabilities, the capabilities shall be activated using any standard or optional hardware provided by the manufacturer, and the UUT shall be connected to a live physical network (including wireless Radio Frequency (RF)).

a. The network shall support the highest and lowest data speeds of the UUT's network function.

b. An active connection is defined as a live physical connection over the physical layer of the networking protocol.

c. If the UUT is equipped with multiple network capabilities, only one connection shall be made in the following order of preference:

i. Cellular modem;

ii. Wi-Fi (Institution of Electrical and Electronics Engineers - IEEE 802.11- 2007[3]);

iii. Ethernet (IEEE 802.3). If the UUT supports Energy Efficient Ethernet Defined in Clause 78 of IEEE 802.3 (originally specified in IEEE 802.3az)[4], then it shall be connected to a device that also supports IEEE 802.3az; or

iv. Other.

[3] 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

[4] IEEE 802 – Telecommunications and information exchange between systems – Local and metropolitan area networks – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

Note: A stakeholder recommended prioritizing a cellular network connection over Wi-Fi or Ethernet for DC EVSE because they are typically installed in outdoor public locations without permanent Wi-Fi or Ethernet connection. They suggested clarifying that the definition of standby-active low mode can be found in CEA 2037-A. Lastly, they recommended combining the network activation requirements from the Test Conduct section with the Full Network Connectivity Testing from the Test Procedures section of the test method.

EPA has edited the list of network connections to prioritize a cellular network connection, as it appears to be the most likely connection for DC EVSE, which are often installed in locations that do not have Wi-Fi availability. Also, EPA has clarified that the definition for standby-active low mode can be found in the CEA 2037-A standard.

d) The tester shall configure the address layer of the protocol, taking note of the following:

i. Internet Protocol (IP) v6 has Neighbor Discovery and will generally configure a limited, non-routable connection automatically.

ii. IP can be configured manually or 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.

e) The UUT shall maintain this live connection to the network for the duration of testing, disregarding any brief lapses (e.g., when transitioning between link speeds).

f) Ensure there is a connection to the Wide Area Network if required in the manufacturer's instructions.

g) If the UUT needs to install any software updates, wait until these updates have occurred; otherwise, if it will operate without updates, skip these updates.

h) In the case of a UUT that has no data/network capabilities, the UUT shall be tested as-shipped.

C) Luminance Testing for Products with a Display: Luminance testing shall be performed for all products at 100% of screen brightness possible as measured in Section 6.2 of the ENERGY STAR Test Method for Determining Display Energy (Rev. Sep-2015).

1) If the UUT cannot display the three-bar pattern specified in IEC 62087:2011, Section 11.5.5, through an external port or network connection, the UUT shall be tested using the default image that appears as-shipped.

a) If the UUT can display the three-bar pattern: Measure the luminance in the center white bar of the three-bar pattern. Ensure that the luminance meter measurement area does not overlap any black bar area.

b) If the UUT cannot display the three-bar pattern and the default as-shipped image is used: Measure luminance in the brightest area of the screen where the measurement area is between 0.4 square inches and 0.6 square inches.

Note: EPA has included more specific instructions on how to measure screen luminance for products that can display the three-bar patter and those that cannot, in order to ensure repeatable results.

D) Display Brightness for Products without Automatic Brightness Control (ABC) Enabled By Default: If the UUT has a display the brightness of which is controllable by the user and does not have ABC enabled as-shipped:

1) The display shall be adjusted to 65% of the maximum brightness available on the display during all testing, or a setting available that is closest to 65%, to within the tolerance of the adjustments available on the EVSE (e.g., if the EVSE provides settings resulting in 50% and 75% of maximum brightness, choose the 75% setting).

2) Following this initial set-up, power testing shall be conducted with the default image that appears as-shipped.

E) Room Illuminance Conditions for Products with ABC Enabled by Default: All products with ABC enabled by default shall be tested in No Vehicle Mode, Partial On Mode, and Idle Mode in two illuminance conditions—light and dark—to simulate daytime and nighttime conditions as specified below. To test products with ABC enabled by default in Operation Mode, the ABC sensor shall be disabled. If the ABC sensor cannot be disabled, the UUT shall be tested in an illuminance condition less than or equal to 1 lux. Following this initial set-up, all power testing shall be conducted with the default image that appears as-shipped.

1) Lamp Type:

a) Standard spectrum halogen reflector lamp. The lamp shall not meet the definition of "Modified spectrum" as defined in 10 CFR 430.2 - Definitions[5].

b) Up to two lamps may be used as long as the lamps are aligned such that each bulb is pointing at the light sensor and the bulbs are as close together as possible.

c) Bulbs with varying rated brightness may be used but they should be able to achieve 10,000 lux at 3.5 feet.

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 3.5 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).

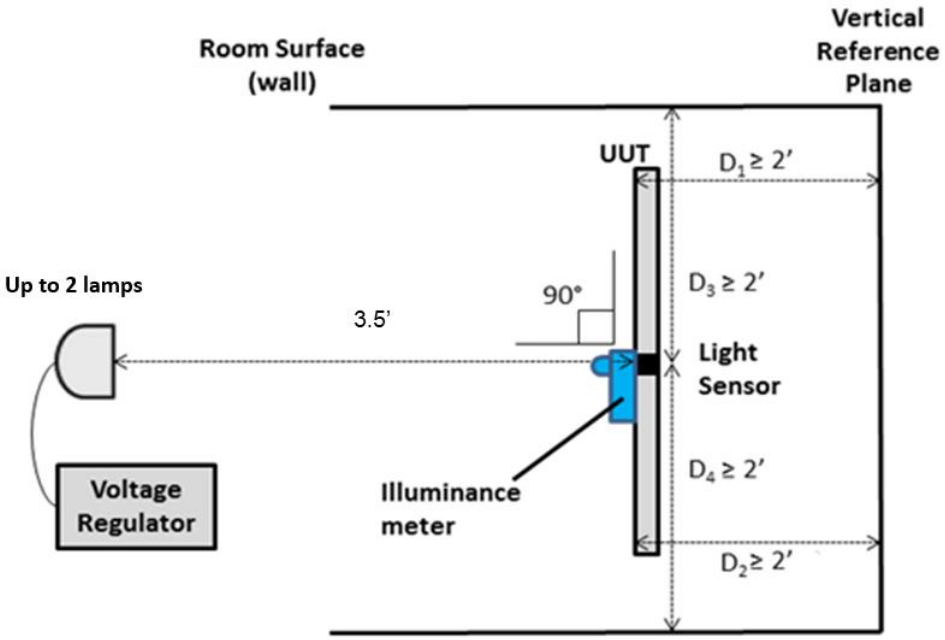
e) No test room surface (i.e., floor, ceiling, and wall) shall be within 2 feet of the center of the UUT's ABC Sensor.

f) Illuminance values shall be obtained by varying the input voltage of the lamp.

g) Figure 4 and Figure 5 provide more information on UUT and light source alignment.

[5] http://www.gpo.gov/fdsys/pkg/CFR-2011-title10-vol3/pdf/CFR-2011-title10-vol3-sec430-2.pdf

346



347

348 **Figure 4: 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

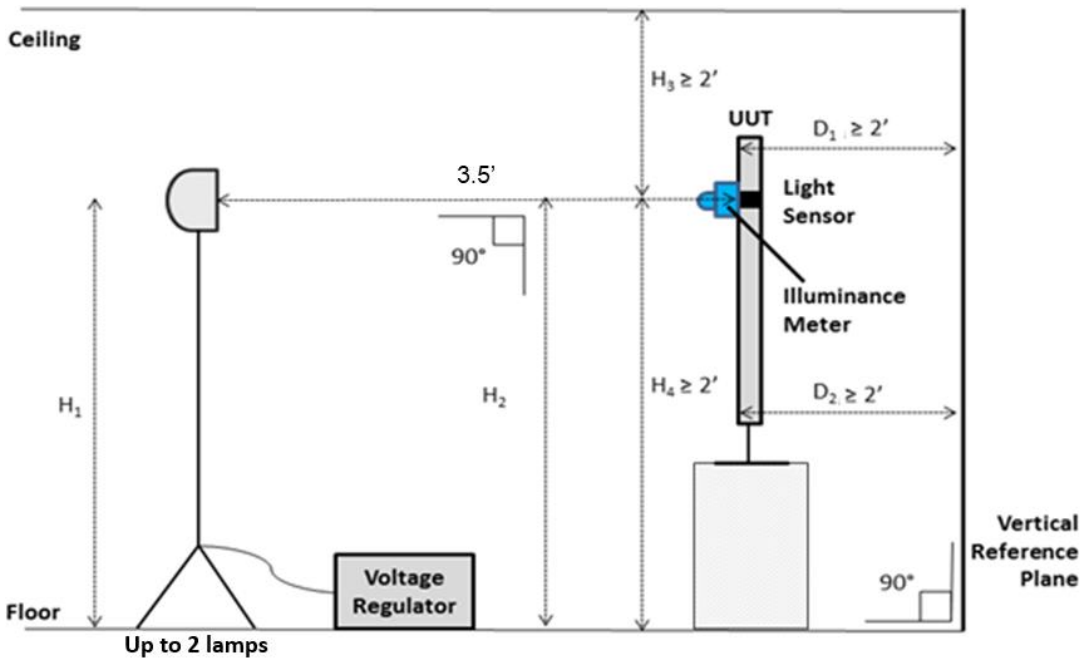


Figure 5: Test Setup - Side View

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
- $H_1 = H_2$ 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 shall be removed for power measurements, after target illuminance achieved

3) Setting Illuminance Conditions:

a) Power shall be disconnected from the UUT.

b) An illuminance meter shall be placed vertically, parallel to the UUT standing upright, such that the meter's sensor faces away from the UUT horizontally.

c) The illuminance meter shall be placed immediately in front of the UUT's automatic brightness control (ABC) sensor.

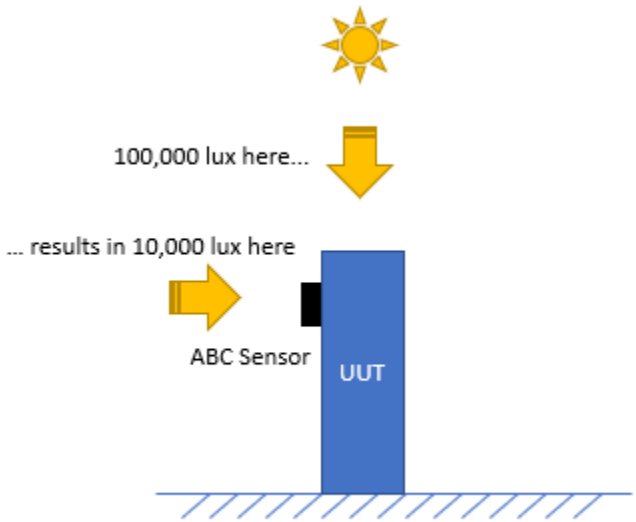
d) The lamp shall be adjusted such that the illuminance meter reads 10,000 ± 400 lux.

e) The illuminance meter shall be removed after target illuminance has been achieved and all testing conducted under the specified illuminance conditions.

f) After all testing has been completed under the high-illuminance conditions, the above steps a) through e) shall be repeated with a target illuminance equal to 10 ± 1.0 lux.

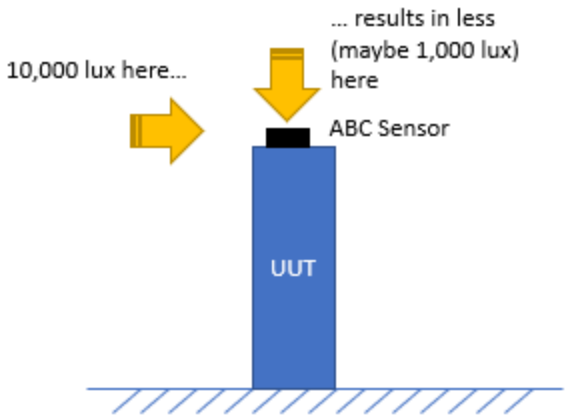
Note: EPA clarified that testing for products with ABC enabled by default should be done with the default image that appears as-shipped. EPA indicated that testing at the light and dark illuminance conditions for products with ABC enabled by default should only be conducted during standby mode testing (No Vehicle Mode, Partial On Mode, and Idle Mode). EPA does not believe that product luminance will have a large impact on power consumption during Operation Mode testing and as a result, proposes that products with ABC enabled be tested with the ABC sensor disabled in Operation Mode, if possible. If it is not possible to disable the ABC sensor, EPA specifies that the product be tested in dark conditions (less than or equal to 1 lux) to ensure repeatable and comparable results. EPA hopes this proposal will reduce testing burden while still encouraging an appropriate implementation of ABC, which will be incentivized in the forthcoming specification criteria. EPA would appreciate feedback from stakeholders on the implementation of ABC in the different standby modes – is ABC implemented similarly across these modes or is there a difference in how the product responds depending on if a vehicle is connected or not?

Also, a stakeholder noted that since DC EVSE are typically installed outdoors, where ambient light levels may be one or two magnitudes higher than an indoor environment, EPA should consider changing the illuminance testing conditions to a brighter test environment, if possible, or setting the display to **its brightest possible setting.** EPA and DOE have reviewed typical outdoor daytime illuminance conditions in North America and found that 1,000–100,000 lux illuminance is typical on a horizontal surface (conditions ranging from overcast to direct sunlight). Furthermore, 100,000 lux pointed perpendicularly onto a horizontal surface, would result in approximately 10,000 lux on a vertical (or side) surface, which is how ABC sensors are expected to be mounted (similar to the user interface elements), as illustrated below:



EPA is proposing to allow for lamps with varying rated brightness to increase the lamp options available to testing laboratories, as long as up to two aligned next to one another pointing at the ABC sensor can achieve a combined brightness of 10,000 lux ± 400 lux. EPA has also proposed to decrease the distance of the UUT (3.5 feet) to increase the illuminance on the ABC sensor. EPA is permitting the use of up to two lamps to achieve the desired illuminance condition, while ensuring repeatable test results. EPA has found several narrow spot (9-10° beam angle) lamps that are readily available that can achieve the illuminance conditions specified.

EPA would appreciate stakeholder feedback on this proposal, especially the expected location and orientation of ABC sensors, such that the test is representative of lighting conditions. EPA wants to ensure that ABC sensors are not likely to be mounted facing up or down, where they would be expected to receive much greater or less illuminance, respectively, than the 10,000 lux proposed in the test method, such that the test would not be representative. For example, an ABC sensor mounted horizontally on the top of the UUT, would be expected to receive 100,000 lux in direct sunlight, but only 1,000 lux under the proposed test method, as illustrated below:



F) Test Conditions for Products with an Occupancy Sensor Enabled by Default:

1) Products with an Occupancy Sensor shall be positioned facing away from any testers, or have the sensor covered or otherwise disabled to be in an open position for the duration of the test.

G) Luminance 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 be accurate to ± 2% (± 2 digits) of the digitally displayed value.
3) Non-contact luminance meters shall have an acceptance angle of 3 degrees or less.

The overall accuracy of a meter is found by taking (±) 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 cd/m^2, 2% of 200 cd/m^2 is 4.0 cd/m^2. The least significant digit is 0.1 cd/m^2. “Two digits” implies 0.2 cd/m^2. Thus, the displayed value would be 200 ± 4.2 cd/m^2 (4 cd/m^2 + 0.2 cd/m^2). The accuracy is specific to the illuminance meter and shall not be considered as tolerance during actual light measurements.

H) Measurement Accuracy for All Products:

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 showing the default image that appears as-shipped.

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

   a) At 10 lux, ambient lighting shall be within ± 1.0 lux; and

   b) At 10,000 lux, ambient lighting shall be within ± 400.0 lux.

7 TEST PROCEDURES FOR ALL PRODUCTS

7.1 UUT Preparation

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) Verify the VEM output is connected to the DC load

3) Connect the power meter as described in Section 4.D) .

4) Determine the maximum available output power of the UUT by using the VEM to communicate with the UUT via the protocol defined for the connector type intended to ship with the product (e.g., for CCS connector type, the VEM shall communicate via the SAE J1772 pilot signal).

5) Provide input power to the EVSE input connection(s).

6) Power on the UUT and perform initial system configuration, as applicable.

7) Ensure the UUT settings are in their as-shipped configuration, unless otherwise specified in this Test Method.

8) Report the test room ambient temperature, relative humidity, and the presence of ABC and occupancy sensors.

B) For EVSE with an integral battery bank, the battery shall be disabled, if possible. If it cannot be disabled, the internal battery shall be at full charge prior to testing.

C) If the EVSE has multiple connector types, choose the one that has the highest power or current rating for the following tests.

7.2 No Vehicle Mode (E.g., SAE J1772 State A) Testing

A) No Vehicle Mode testing shall be conducted for all products.

B) Conduct the UUT preparation procedure in Section 7.1

C) Verify the UUT output connector is unplugged from VEM.

D) Measure and record UUT input power: $P = \frac{1}{T}\int_0^T v_{in}(t) \times i_{\text{in}}(t)dt$

E) Power shall be measured according to IEC 62301 Ed 2.0-2011; with the additional guidance in Section 6 of this document.

7.3 Partial On Mode (E.g., SAE J1772 State B) and Idle Mode (E.g., SAE J1772 State C) Testing

A) Conduct the UUT preparation procedure in Section 7.1

B) Ensure any demand-response functionality or timer is disabled.

1) If demand-response functionality or timer cannot be disabled and a demand-response or timer function occurs during a test, the results from the test shall be replaced with results from a substitute test.

C) Conduct the following procedure to measure the UUT power consumption:

1) State C[6]: Plug in the UUT output connection to vehicle inlet on a VEM and enter State C. Measure and record:

a) UUT input power; $P = \frac{1}{T}\int_0^T v_{in}(t) \times i_{in}(t)dt$

b) UUT output current I_{out} (to verify zero output current).

2) State B[7]: Plug in the UUT output connection to vehicle inlet on the VEM. Wait 2 minutes and then measure and record UUT input power: $P = \frac{1}{T}\int_0^T v_{in}(t) \times i_{in}(t)dt$

D) Power shall be measured according to IEC 62301 Ed 2.0-2011; with the additional guidance in Section 6 of this document.

7.4 Operation Mode (State C) Testing[8]

A) Ensure any demand-response functionality or timer is disabled.

1) If demand-response functionality or timer cannot be disabled and a demand-response or timer function occurs during a test, the results from the test shall be replaced with results from a substitute test.

B) Determine the UUT available current.

1) Backfeeding the source may be used in place of a test load during testing of EVSE systems, provided that an output power factor greater than 0.99 is maintained at all times.

2) Conduct the UUT preparation procedure in Section 7.1.

3) For multiple-output EVSE, the available current shall be the maximum current that can be provided by the unit when a single output is being used (i.e., no derating/current sharing). The unit shall be configured to provide this maximum current.

4) State C[9]: Plug in the UUT output connection to vehicle inlet on VEM.

C) Warm-up

1) Ensure the unit is kept at ambient temperature for 30 minutes prior to the test.

2) Engage the load and draw 10 kW as specified in Table 5 for 5 minutes or more.

3) Only one warm-up period of 5 minutes is required for each unit under test at the beginning of the test procedure.

[6] This state name refers to SAE J1172. If using a SAE J1772-compliant VEM, switch it to State C by closing switch S2. If testing using another protocol, enter the sate which represents a vehicle connected and ready to accept current.

[7] This state name refers to SAE J1172. If using a SAE J1772-compliant VEM, switch it to State B by opening switch S2. If testing using another protocol, enter the sate which represents a vehicle connected but not ready to accept current.

[8] This state is similar to Charging and Maintenance Modes in SAE J2894-2; however, there may be some discrepancies due to network configuration, the lack of a connected battery, and discrete number of power values tested.

[9] This state name refers to SAE J1172. If using a SAE J1772-compliant VEM, switch it to State C by closing switch S2. If testing using another protocol, enter the sate which represents a vehicle connected and ready to accept current.

Note: EPA expects the majority of DC EVSE to use active cooling, with more cooling (and additional losses due to cooling) expected at higher loads. Moreover, EPA expects there to be a "power overhang"; i.e., the EVSE will not immediately disable or turn down the cooling after the load is decreased. Therefore, to prevent the cooling losses at higher load from being reflected in the test results at lower loads (where they could have a bigger impact on efficiency) EPA proposes to reverse the test order relative to AC EVSE and test from lower to higher load. EPA welcomes feedback on this proposal and how to best ensure that a relatively short operation mode test is nonetheless representative of typical operation.

D) Measurement

1) After the 5-minute warm-up period, the technician shall monitor input current for a period of 5 minutes to assess the stability of the unit under test.

a) If the input current level does not drift by more than 0.2 percent from the maximum value observed over the 5-minute period, the unit under test can be considered stable and measurements can be recorded at the end of the 5-minute period.

Note: EPA received stakeholder feedback that a 1% drift in input current during this warm-up period could lead to significant variation in resulting efficiency measurements. As a result, and in response to stakeholder suggestions to decrease this to 0.2%, EPA has updated the allowable input current drift during the warm-up period.

b) If input current is not stable over a 5-minute period, the technician shall follow the guidelines established by IEC Standard 62301 for measuring average power or accumulated energy over time for both input and output.

2) The following measurements and calculated values shall be recorded after the 5-minute stabilization period:

a) RMS input current or DC-input current;

b) RMS input voltage or DC-input voltage;

c) Power Factor (PF) (not applicable for DC-input)

d) Total Harmonic Distortion (THD) (not applicable for DC-input)

e) DC-output current for each output;

f) EVSE input power: $P_{INPUT} = \frac{1}{T}\int_0^T i_{in}(t) \times v_{in}(t)dt$

g) EVSE output power: $P_{OUTPUT} = \frac{1}{T}\int_0^T i_{out}(t) \times v_{out}(t)dt$

Note: A stakeholder noted that power factor, apparent power, and RMS measurements are not applicable for DC-input EVSE. They requested that EPA include measurements for DC power sources as well. EPA has clarified that these measurements are only applicable to AC-input EVSE and specified measurement of DC power.

In addition, EPA has included total harmonic distortion as an additional measurement to record because power factor and THD are measures of power quality, which can be important to electric utilities when serving large commercial loads.

3) Repeat for all loading conditions in Table 5 that are less than or equal to the full current output capability of the UUT, in sequence from Loading Condition 2 to Loading Condition 5 for AC-input or 4 for DC-input.

4) Measurements at subsequent loading conditions shall be conducted under the 5-minute stability guidelines in Section 7.4.D)1), above.

5) At the conclusion of Operation Mode testing, return to Idle State (zero output current) and record the power until the measured power draw returns to that measured in Section 7.3.

Note: One stakeholder stated that off-grid DC EVSE must have an internal battery to power internal electronics since there is no utility presence to do so and as a result, testing should be done with the battery enabled for these products. Another manufacturer recommended that EPA specify that:

• The battery should be fully discharged to ensure that batteries do not provide stored energy to the EVSE during the test (since energy from the battery would not be captured by the test), or

• The manufacturer could start and end the test with batteries fully charged if they are willing to accept any potential energy consumption that occurs when the batteries are discharged during the test and then recharged.

They also recommended that in a future specification, EPA could include testing for use of energy storage to power DC EVSE, if this type of product becomes common.

EPA will continue to require that an integral battery be disabled, if possible. However, for DC EVSE that contain a battery that is not able to be disabled, EPA has provided additional instructions for testing due to these stakeholder concerns that the battery may cause inaccurate results due to either the product using the battery to provide power, rather than input AC. As a result, for DC EVSE that contain a battery that cannot be disabled, EPA will continue to require that the integral battery be fully charged prior to testing but that the power consumption will continue to be monitored and measured after each modal test until there is no more power draw, in order to account for any energy used to recharge the battery.

Table 5: Loading Conditions for AC-input UUT

	Test Condition Current (A)	Example for 150 kW capable UUT	Example for 50 kW capable UUT
Loading Condition 1	10 kW ± 0.2 kW and 350 V ± 7 V	10 kW	10 kW
Loading Condition 2	30 kW ± 0.6 kW and 350 V ± 7 V	30 kW	30 kW
Loading Condition 3	50 kW ± 1 kW and 350 V ± 7 V	50 kW	50 kW
Loading Condition 4	150 kW ± 3 kW and 400 V ± 8 V	150 kW	N/A
Loading Condition 5	Max Available Power Output (determined in Section 7.4.B), above) ± 2% and Voltage= Pout / 0.7 A + 300 V ± 2%.	N/A	N/A

Note: Per the proposed limitation of scope, EPA has removed the 350 kW test condition from Table 5 since the maximum available output power for a DC EVSE with a rated output of 350 kW will be captured in Loading Condition 5. For the maximum power, EPA is proposing a voltage that is calculated from the maximum power by dividing by 0.7 A and adding 300 V, to provide a voltage proportional to power, and results in 800 V at 350 kW. EPA would appreciate stakeholder feedback on the equation to calculate the appropriate voltage at the maximum output power loading condition.

Table 6: Loading Conditions for DC-input UUT

	Test Condition Current (A)
Test Condition 1	Maximum Input Current ± 2%.
Test Condition 2	30.0 A ± 0.6 A
Test Condition 3	15.0 A ± 0.3 A
Test Condition 4	4.00 A ± 0.1 A

Note: A stakeholder noted that off-grid solar-powered DC EVSE are not capable of delivering precise loading conditions, instead they deliver the current available from the sun which varies between ~ 0 W - 20 kW. They suggested that EPA add a loading condition of 0 W to Table 3 for off-grid DC EVSE. They also suggested that EPA consider DC-input EVSE in the measurements and calculated values that need to be recorded during Operation Mode testing.

EPA is proposing to reuse the test table from the current AC-output EVSE test method, except since DC-input EVSE are expected to be driven by a solar PV array which acts as a current source, it will be the input current that will be varied rather than the load. The 0 W condition is already tested as Idle State.

7.5 Full Network Connectivity Testing

A) For products with data/networking capabilities, the presence of Full Network Connectivity shall be determined by testing the UUT for network activity in Partial On Mode according to Section 6.7.5.2 Method 1 of Consumer Electronics Association (CEA) 2037-A, Determination of Television Set Power Consumption, with the following guidance:

   1) The UUT shall be connected to a network per Section 6.1.B)2) of this test method prior to the test; and

   2) The UUT shall be placed into Partial On Mode in place of Standby-active, Low Mode, as defined in CEA 2037-A.

Note: A stakeholder suggested clarifying that the definition of standby-active low mode can be found in CEA 2037-A. EPA has clarified that the definition for standby-active low mode can be found in the CEA 2037-A standard.

Note: EPA is aware that EVSE are increasingly being installed in conjunction with battery storage. EPA would like to continue discussions with stakeholders on how to appropriately account for battery storage input in this test method.