ENERGY STAR® Program Requirements for Electric Vehicle Supply Equipment

Test Method for DC EVSE
Final Draft

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

The following test method is applicable to all products eligible for certification under the ENERGY STAR Product Specification for DC EVSE.

Note: EPA clarified the applicability section by indicating that this test method is applicable for all products after a stakeholder suggested this section may cause confusion on which sections of the test method are mandatory.

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 from the premises wiring (if available) 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: A stakeholder believed that the change to the EVSE definition in the Draft 2 to remove the term 'premises wiring' was unnecessary because the NEC definition of premises wiring includes off-grid systems (e.g., off-grid solar PV EVSE systems that do not draw energy from an external source). EPA has again included the term 'premises wiring' in the EVSE definition but clarified that it is relevant only if available to prevent confusion 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.

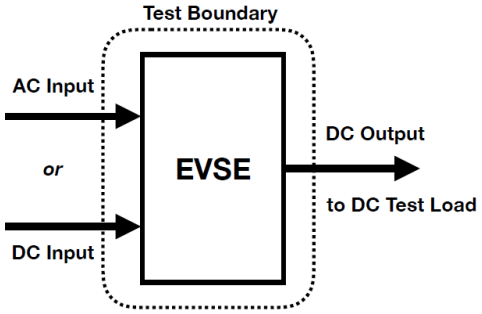


Figure 1: Schematic of DC-Output EVSE Test Boundary

Note: A stakeholder noted that the schematic of the test boundary is unclear because of how the arrows are configured. As a result, EPA has updated Figure 1 to clearly demonstrate the boundary conditions for this test method.

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

Note: A stakeholder pointed out that the definition of Cabinet/Dispenser configuration should allow for multiple cabinets and dispensers. EPA has altered the definition to account for products that have multiple cabinets/dispensers.

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.

In Draft 2, EPA proposed to include equipment with output power less than or equal to 350 kW, given the nascent state of the market for larger DC-output EVSE. EPA expects this to include the majority of products available today. In addition, EPA proposed to separate DC-output EVSE into three bins, based on maximum output power, to set criteria as shown here:

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

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	✓	✓	

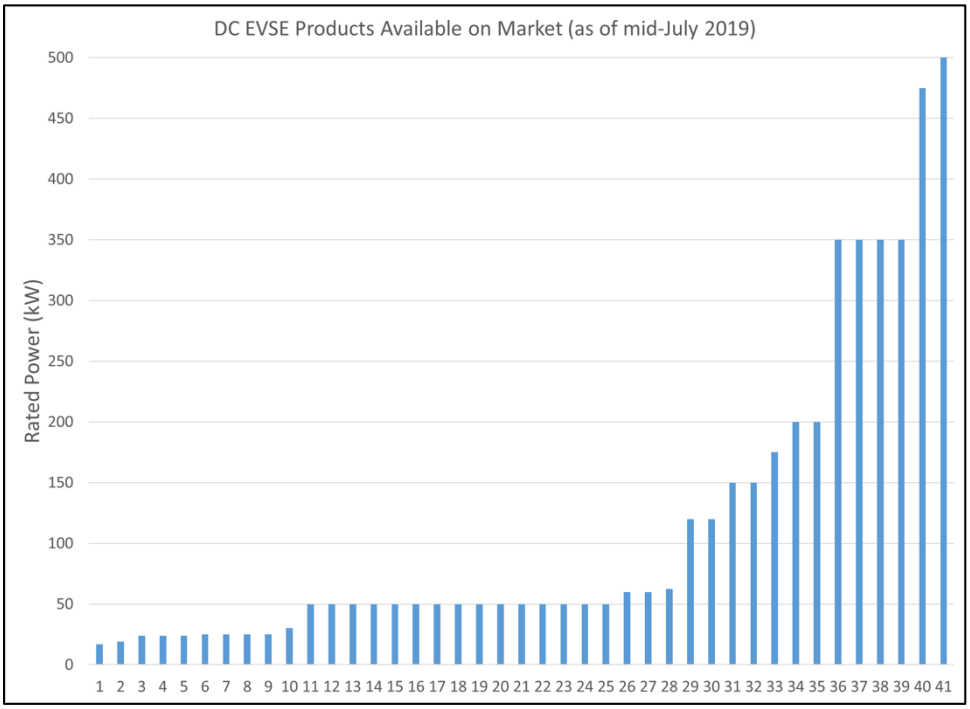
EPA received the following feedback on this proposal:

• A stakeholder proposed that the lowest power bin listed in the proposed scope (products ≤ 50 kW) be increased to include products ≤ 100 kW.

• Another stakeholder recommended that the scope not be limited for DC charging because demarcations will cause complexity, difficulty in testing, and will make it hard to change later. As a result, this stakeholder suggested a single classification for DC charging (from 0 to infinity kW) so that design options are not limited to fit into arbitrary classifications and consumers do not have limited options if they want an ENERGY STAR certified product. They also questioned why operating efficiency is only required for units under 50 kW.

• Another stakeholder recommended that EVSEs with an output power up to 150 kW have operational efficiency benchmarks to evaluate performance, if data are available to evaluate their performance. They noted that there are over 5,700 DC EVSE installations planned with an output power between 50 kW and 150 kW. They agreed that the scope for Version 1.1 should include DC-output EVSE up to 350 kW.

In response to these comments, EPA reviewed the DC EVSE products available on the market currently and compiled this information based on publicly available online sources:



EPA observed that a significant number of products available today are rated at 50 kW output. There are three products available that are slightly above 50 kW, 60 – 65 kW, that EPA believes would be similar in nature (technologically and in electrical design) to the 50 kW products. As such, EPA has edited the proposed bins (as demonstrated below) to raise the lowest size bin to include all products below and including those rated at 65 kW. Some stakeholders suggested EPA expand this first bin further however the next grouping of available products is around 120 kW. EPA understands from stakeholder discussions that there is a clear distinction between the products under 65 kW and those above. Further, performance data for models beyond 65 kW is not widely available at this time. EPA will consider setting operation mode requirements for these larger capacity products in the future when data is available.

DC EVSE Output Power	**≤ 65 kW**	**65 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	✓	✓	

EPA chose to group these products into distinct categories with fewer requirements for high power EVSE in response to stakeholder feedback that larger DC-output EVSE are newer to market, not as commoditized and more customizable, and there is a lack of data on efficiency for these products. EPA agrees that operating efficiency is a key metric for consumers and hopes to include criteria for the products with output power greater than 65 kW up to 350 kW in a future revision of the specification once data is available. At this time, EPA is still requiring that operation mode test results be reported on the Certified Product List in order to provide consumers with this information.

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

4.2.2 Pantograph EVSE (chargers with an automated connection system, or ACS)

4.2.3 Wireless / Inductive EVSE

Note: In Draft 2, EPA also proposed to exclude pantograph EVSE (chargers with an automated connection system, or ACS) from the scope of the Version 1.1. A stakeholder requested clarification on the exclusion of pantograph charging stations. EPA excluded pantograph charging stations because standard operating parameters for these product types are still under development. In addition, the testing and resulting losses and efficiency values for these products would need to be analyzed differently than the products currently included in this effort because of the connector type. In the Version 1.1, EPA is focused on including DC EVSE intended for charging light duty vehicles. EPA plans to re-evaluate pantograph charging stations for inclusion in a future revision of the EVSE specification.

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.

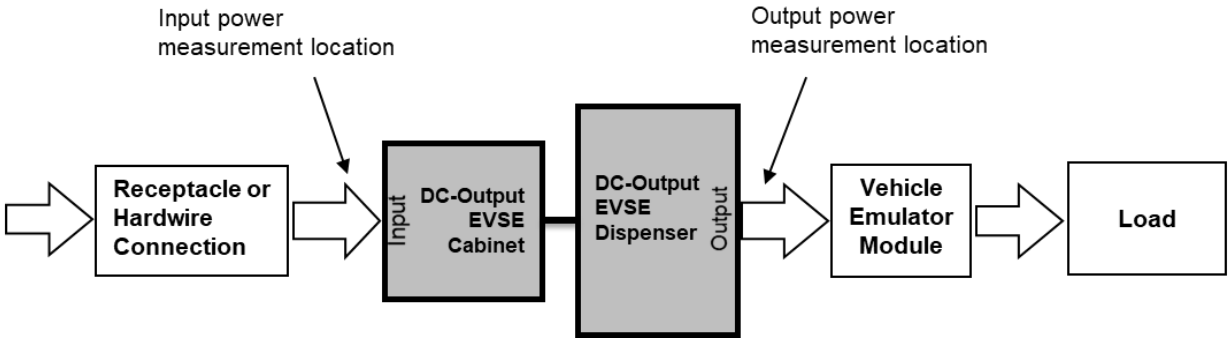


Figure 1a: Schematic of test setup connection for a cabinet/Dispenser Product Configuration. The two components are in one enclosure in an All-in-One Product Configuration

Note: A stakeholder recommended reorienting the arrow pointing to the 'Input power measurement location' to point to the word 'Input'. EPA updated Figure 1a to better indicate where the points of measurement will take place.

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 highest 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: In response to the proposal in Draft 2 to test DC-input products at the nameplate rated voltage, two stakeholders recommended that if multiple rated voltages are specified, EPA consider testing at the highest rated voltage. EPA agrees with these stakeholders and has specified that the highest nameplate rated voltage should be used as the input for testing.

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. Measurements shall be made at the locations as shown in Figure 2. If necessary, fabricate an input wiring apparatus so that measurements can be made without modifying the EVSE input cord(s). .

a) Voltage Measurements shall be performed as shown in Figure 2.

b) Current Measurements shall be performed as shown in Figure 2.

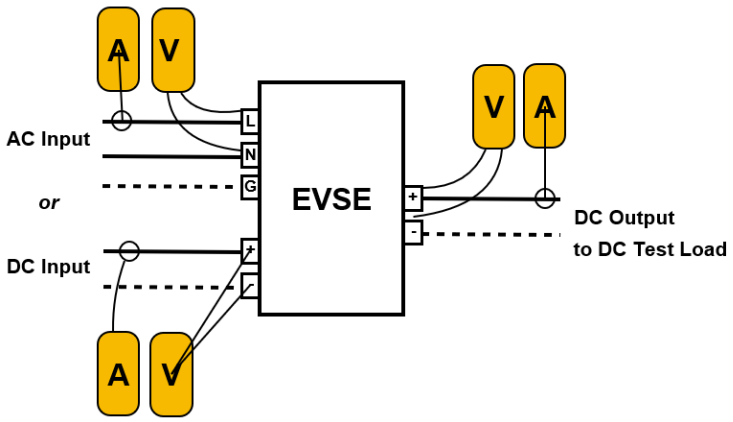


Figure 2: Schematic of Measurement Locations

Note: EPA updated Figure 2 to clarify where the voltage and current measurement locations should be performed. In doing so, the reference to an Input Measurement Apparatus was removed and the instructions above the figure were edited accordingly.

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 4 for all portions of the test.

a) Once the temperatures in Table 4have been attained, the UUT shall remain in the test chamber at the specified temperature for 2 hours prior to power testing.

b) UUTs shall be tested at all three ambient temperatures in Table 4 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 4: Ambient Test Temperatures for All DC EVSE

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: In Draft 2, EPA proposed that DC EVSE without active heating and cooling only need to test in the temperate temperature condition for all modes of operation. In response, a stakeholder recommended that EPA consider temperature effects on operational mode efficiency for all products, including those without active cooling or heating. They noted that efficiency for these products can vary widely from -7ºC to 40 ºC because of increased resistivity with an increase in temperature. As a result, EPA is requiring that all products be tested according to the temperature conditions in Table 4.

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).

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

a) Able to meet the rated capability of the UUT (e.g., sink current up to the rated current of the UUT); and

b) Controllable voltage and current levels capable of achieving power levels detailed in Table 3.

Note: A stakeholder requested that EPA remove references to voltage and other specific details of the test load and instead state more generally that the load must be able to meet the capabilities of the charging station and the required test conditions. EPA made changes to reflect this feedback for simplicity.

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

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.

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).

l) 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.

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:

a) 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.

b) 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[2]);

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)[3], then it shall be connected to a device that also supports IEEE 802.3az; or

iv. Other.

c) 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.

d) 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).

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

f) 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.

g) 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. May-2019).

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.

[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] 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

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[4].

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.

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

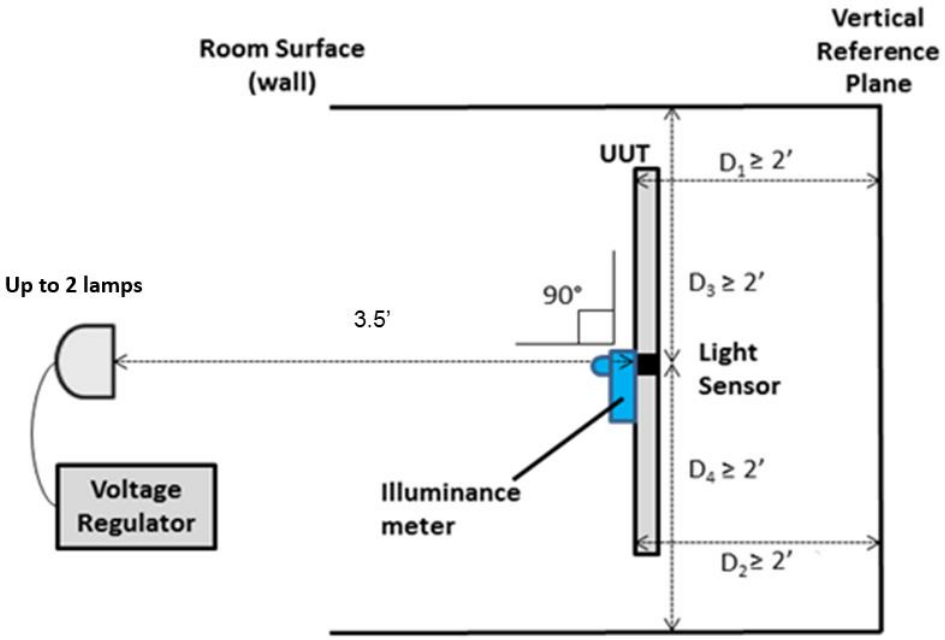


Figure 4: Test Setup - Top View

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

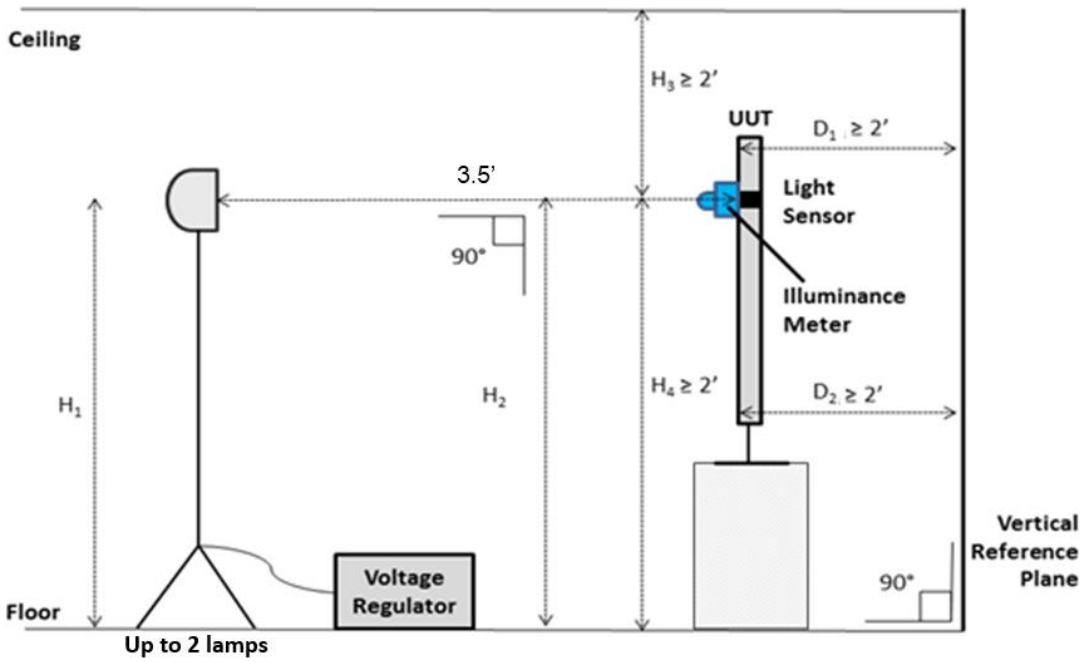


Figure 5: Test Setup - Side View

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.

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 Illuminance Meter:

1) 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.

2) 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.

Note: For clarity, EPA removed requirements pertaining to the accuracy of the power meter because the accuracy of the power meter is already addressed in Section 5H)5).

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, not providing current) 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[5]: 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[6]: 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.

[5] 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.

[6] 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.

7.4 Operation Mode (State C, providing current) Testing[7]

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[8]: 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 3 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.

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.

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) DC-output voltage for each output;

[7] 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.

[8] 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.

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

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

Note: EPA clarified that the DC-output voltage should be measured for each output, in addition to the output current in order to perform the calculations in g) and h).

3) Repeat for all loading conditions in Table 3 that are less than or equal to the full current output capability of the UUT (ignoring any duplicate loading conditions), in sequence of lowest output power to highest output power from Loading Condition 2 to Loading Condition 6 for AC-input and DC-input.

   a) If a UUT cannot achieve the voltage listed, it shall be tested at the mid-point of the available output voltage range.

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

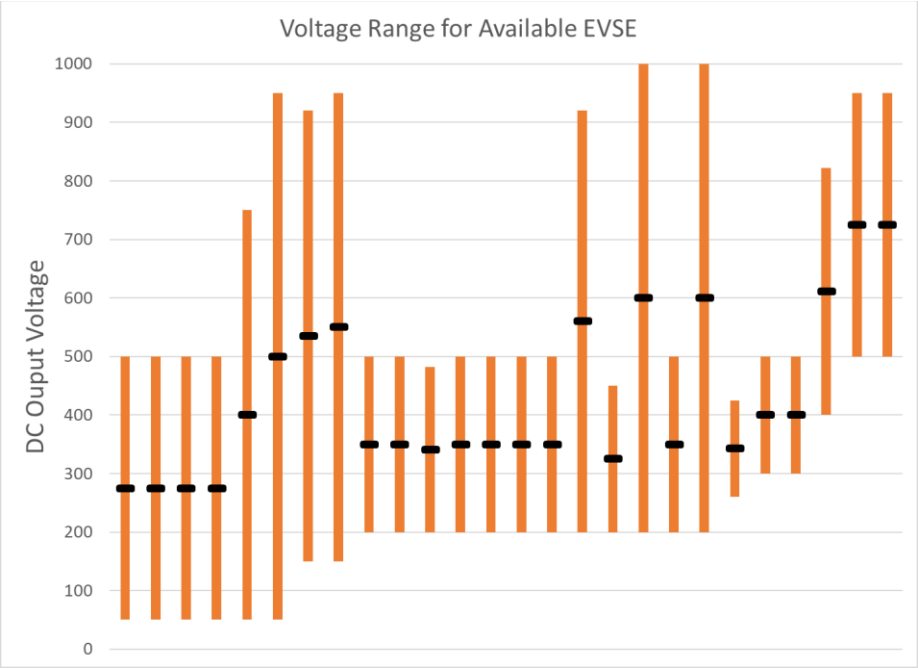
5) At the conclusion of Operation Mode testing, return to Idle State (zero output current) and record the power until the measured power draw returns to that measured in Section 7.3.

Table 3: Loading Conditions for UUT

	Test Condition	Example for 150 kW capable UUT	Example for 50 kW capable UUT
Loading Condition 1	25% of Maximum Available Output Power ± 2% and 350 V ± 7 V	37.5 kW	12.5 kW
Loading Condition 2	50% of Maximum Available Output Power ± 2% and 350 V ± 7 V	75 kW	25 kW
Loading Condition 3	75% of Maximum Available Output Power ± 2% and 350 V ± 7 V	112.5 kW	37.5 kW
Loading Condition 4	50 kW ± 1 kW and 350 V ± 7 V	50 kW	50 kW
Loading Condition 5	150 kW ± 3 kW and 350 V ± 7 V	150 kW	N/A
Loading Condition 6	100% Maximum Available Output Power (determined in Section 7.4.B), above) ± 2% and Voltage= mid-point of available output voltage range	N/A	N/A

Note: Two stakeholders recommended testing at specified percentages of full load conditions, independent of the power rating of the EVSE. EPA agrees with the stakeholder's reasoning for including loading conditions based on percentage of maximum output power. As a result, Table 5 now includes four loading conditions based on various percentages of full output in order to ensure that all products will have four Operation Mode test points resulting in efficiency values across the product's full capability and load profile. EPA retained two fixed measurement conditions of 50 kW and 150 kW after reviewing peak DC charging power for a number of popular EVs on the market today. A significant number of EVs draw a maximum of 50 kW and a typical maximum power draw for EVs with larger battery packs is approximately 150 kW. There are vehicles available today that are capable of drawing a maximum of 200 – 250 kW, but only for relatively short periods of time before the charge rate begins to taper. Maintaining these two exact loading conditions will allow for easy comparison from product to product, while including the loading points at percentages of maximum output power will provide an understanding of how EVSE efficiency varies across load conditions above and below those fixed points of comparison. EPA clarified that the EVSE only needs to be tested once at each loading condition and duplicate loading conditions can be ignored (e.g., for a 150 kW capable EVSE, it would only need to be tested at either loading condition 5 or 6, since both would equal 150 kW).

One stakeholder suggested testing at the same output voltage for all loading conditions since the output voltage is decided by the vehicle rather than the EVSE. Specifically, they stated that 400 V and 800 V would be values to consider to avoid a situation where the EVSE is not able to supply full power due to its output power being limited by its charging cable current rating. Another stakeholder suggested percentages of available output voltage because of a situation where a product may not be capable of an output less than 500 V. In response, EPA analyzed the available voltage ranges of DC EVSE products currently on the market:



EPA chose 350 V across loading conditions 1 through 5 because it appears that most products are capable of 350 V output in this dataset. It is also close to the mid-point voltage for a significant number of lower voltage products. EPA noted that if a product is not capable of 350 V, then the mid-point of the voltage range should be chosen for testing.

Also, a stakeholder suggested substituting a DC voltage source for a PV array for products that are DC-input. They also recommended the Operation Mode Loading Conditions be based on percentages of maximum load, rather than specific values like 30 A, 15 A, and 4 A. EPA combined the tables of loading conditions for AC and DC input so they have the same loading conditions. This was a result of stakeholder feedback and to harmonize the conditions across both types of products for easier comparison. EPA is requiring a DC voltage source for testing DC-input products.

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: 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.