



# ENERGY STAR® Program Requirements for Electric Vehicle Supply Equipment

## Final Test Method Rev. Apr-2017

### 1 OVERVIEW

The following test method shall be used for determining product 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 5.1, 5.2, 5.3, and 5.4 shall be performed on all products.
- The test procedures in Section 5.5 shall be performed on products with network connectivity.

### 3 TEST SETUP

- A) Test Setup and Instrumentation: Test setup shall be in accordance with the diagram in Figure 1a and Figure 1b with additional requirements specified below.

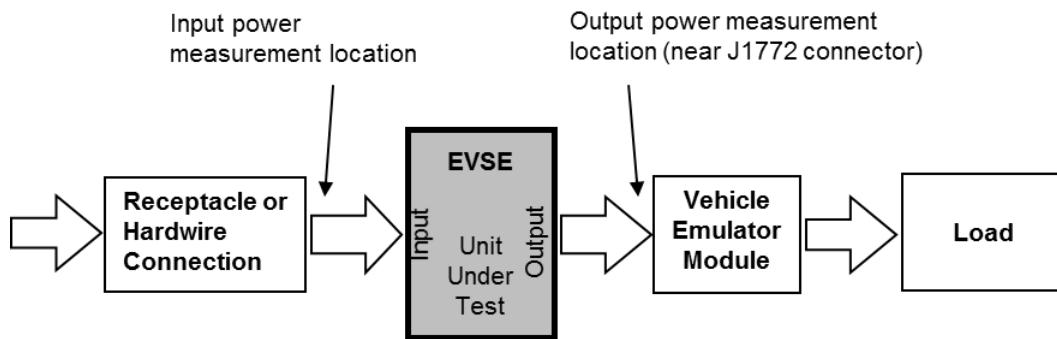
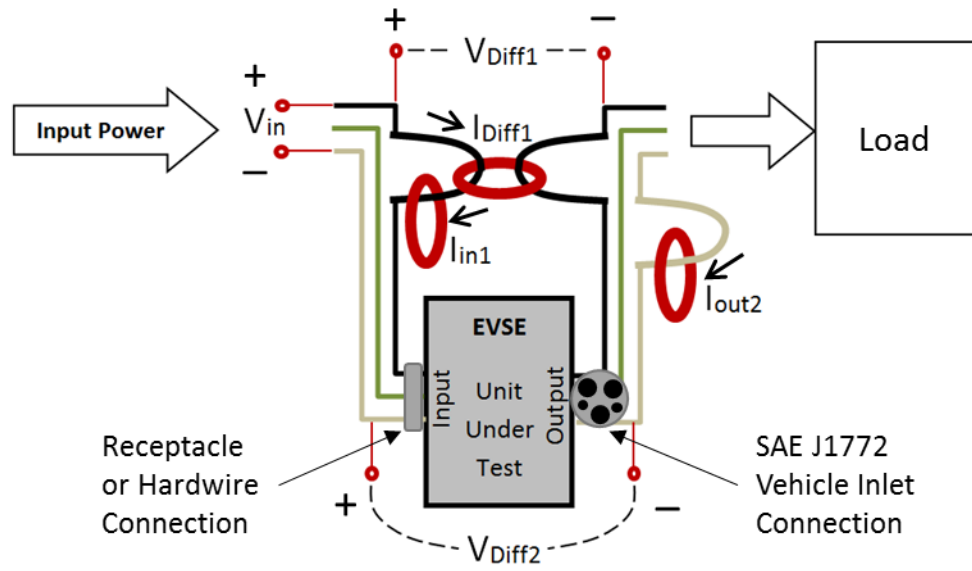


Figure 1a: Schematic of test setup connection



**Figure 1b: Schematic of test setup connection**

The test setup is to be configured to measure the following, as shown in Figure 1b:

- $V_{in}$  : input voltage
- $V_{diff1}$  : differential voltage measurement of Line1 across the EVSE input to the EVSE output
- $V_{diff2}$  : differential voltage measurement of Line2 (or neutral) across the EVSE input to the EVSE output
- $I_{in1}$  : input current measurement of Line1
- $I_{diff1}$  : differential current measurement of Line1 across the EVSE input to the EVSE output
- $I_{out2}$  : output current measurement of Line2 (or neutral)

- B) AC Input Power: The UUT shall be operated at the first (highest) rated voltage and rated frequency combination specified in Table 1.
- 1) 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.
  - 2) UUTs that are designed to operate at multiple voltage ranges (both Level 1 and Level 2 functionality) shall be separately tested for both Level 1 and Level 2 operation. In each test configuration, the UUT shall be operated at the first (highest) rated voltage and rated frequency combination specified in Table 1.
  - 3) The voltage and frequency tolerance shall be as specified in Table 2.

**Table 1: Input Supply Requirements**

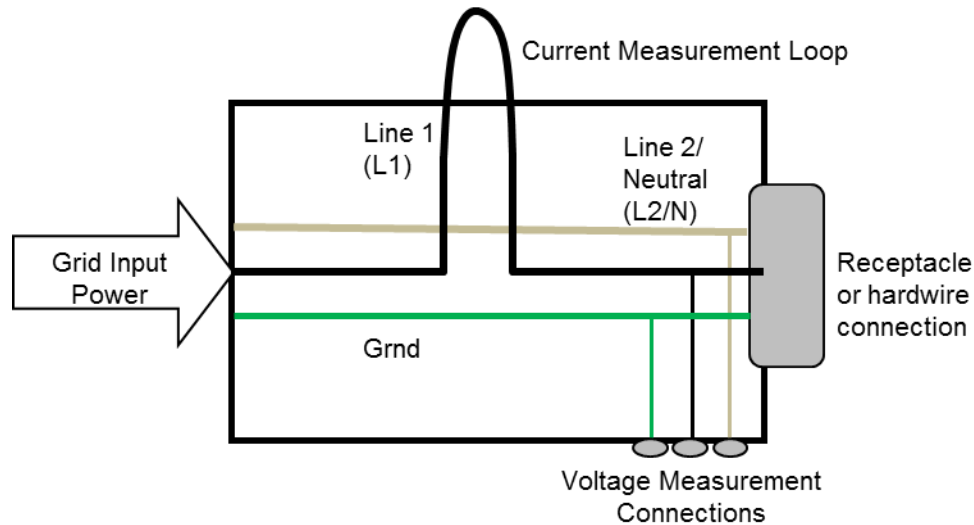
Voltage	Frequency
240 V AC	60 Hz
208 V AC	60 Hz
120 V AC	60 Hz

**Table 2: Input Power Tolerances**

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

C) Input Power Measurements:

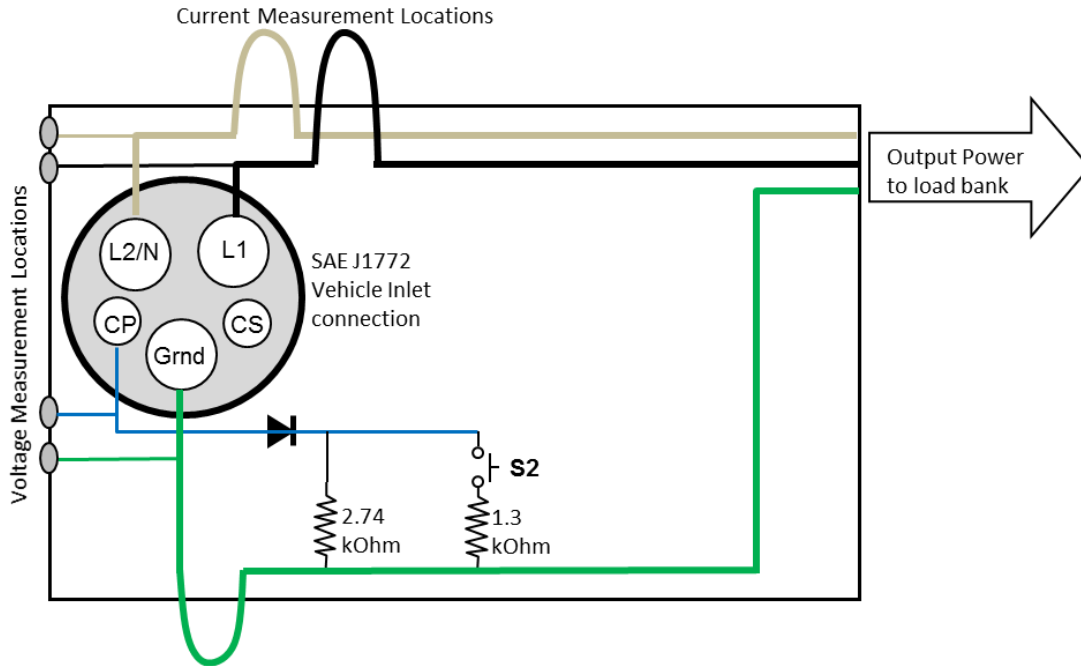
- 1) Cables: All power cables for the test shall be the default provided by the manufacturer
- 2) For EVSE equipped with input plug(s) and cord(s), the corresponding receptacle will be used to provide power to the input plug(s) of the EVSE. If this is a multi-input EVSE, the inputs shall be connected 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 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.
- 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.



**Figure 2: Schematic of Input Measurement Apparatus (IMA)<sup>1</sup>**

- D) Ambient Temperature: Ambient temperature shall remain at  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  for the duration of the test.
- E) Relative Humidity: Relative humidity shall remain between 10% and 80% for the duration of the test.
- F) Test Load: A test load shall be connected to the EVSE output in lieu of a vehicle.
  - 1) Vehicle Emulator Module (VEM): A VEM allows current and voltage measurements of the UUT output without modifying or altering the UUT output cable(s). Figure 3 shows an example schematic of the VEM.
    - a) Output Power Measurement: Insulated current conductor loops or current measurement shunts as well as voltage measurement connections shall be used to measure the UUT output current and voltage.
      - i. If there are multiple output cable options for a given model, the longest available cable shall be used for the test.
    - b) Output Coupler: The SAE J1772 interface shall be used to connect between the UUT and VEM. If the UUT does not have an SAE J1772 output coupler, an adapter shall be provided by the manufacturer.

<sup>1</sup> In a four-conductor system, the conductor labeled L2/N will actually be two separate conductors: L2 and N.



**Figure 3: Schematic of Vehicle Emulator Module (VEM)<sup>2</sup>**

- 2) AC Load: The AC load shall possess the following capabilities
  - a) Sink AC current up to the rated RMS current of the UUT;
  - b) Voltage range within the Level of the UUT (Level 1 or Level 2); and
  - c) Controllable RMS current levels capable of achieving current levels detailed in Table 4.
- G) Power Meter: Power meters shall possess the following attributes:
  - 1) Number of Channels:
    - a) One channel shall be set up to measure the AC power of the internal components of the UUT
      - i. Input voltage measurement ( $V_{in}$ ) and the differential current measurement ( $I_{diff1}$ )
    - b) One channel shall be set up to measure power loss across the EVSE on Line 1
      - ii. Differential voltage measurement of Line 1 ( $V_{diff1}$ ) and the Input current measurement of Line 1 ( $I_{in1}$ )
    - b) One channel shall be set up to measure power loss across the EVSE on Line 2/N
      - ii. Differential voltage measurement of Line 2/N ( $V_{diff2}$ ) and the Output current measurement of Line 2/N ( $I_{out2}$ )
  - 2) 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.
  - 3) Minimum Frequency Response: 3.0 kHz

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

- 4) Minimum Resolution:
  - a) 0.01 W for measurement values less than 10 W;
  - b) 0.1 W for measurement values from 10 W to 100 W; and
  - c) 1.0 W for measurement values greater than 100 W.
- 5) Accuracy: +/- 0.1% of reading PLUS +/- 0.1% of full scale
- 6) Measurements and Calculations:
  - a) Cable Length (ft.);
  - b) Cable Gauge (AWG);
  - c) Power Factor (PF);
  - d) Apparent Power (S);
  - e) Voltage (RMS);
  - f) Current (RMS);
  - g) Average Power (W); and
  - h) Frequency (Hz).

B) Illuminance Meter Accuracy:

- 1) All illuminance meters shall be accurate to  $\pm 2\%$  ( $\pm 2$  digits) of the digitally displayed value.

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 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  $200 \pm 4.2$  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 4.1.E)3).

## 4 TEST CONDUCT

### 4.1 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) The UUT shall be mounted 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. Wi-Fi (Institution of Electrical and Electronics Engineers - IEEE 802.11- 2007<sup>3</sup>);
    - ii. 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)<sup>4</sup>, then it shall be connected to a device that also supports IEEE 802.3az;
    - iii. Cellular modem; or
    - iv. Other.
- d) The tester shall configure the address layer of the protocol, taking note of the following:
  - i. Internet Protocol (IP) 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.

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<sup>3</sup> 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

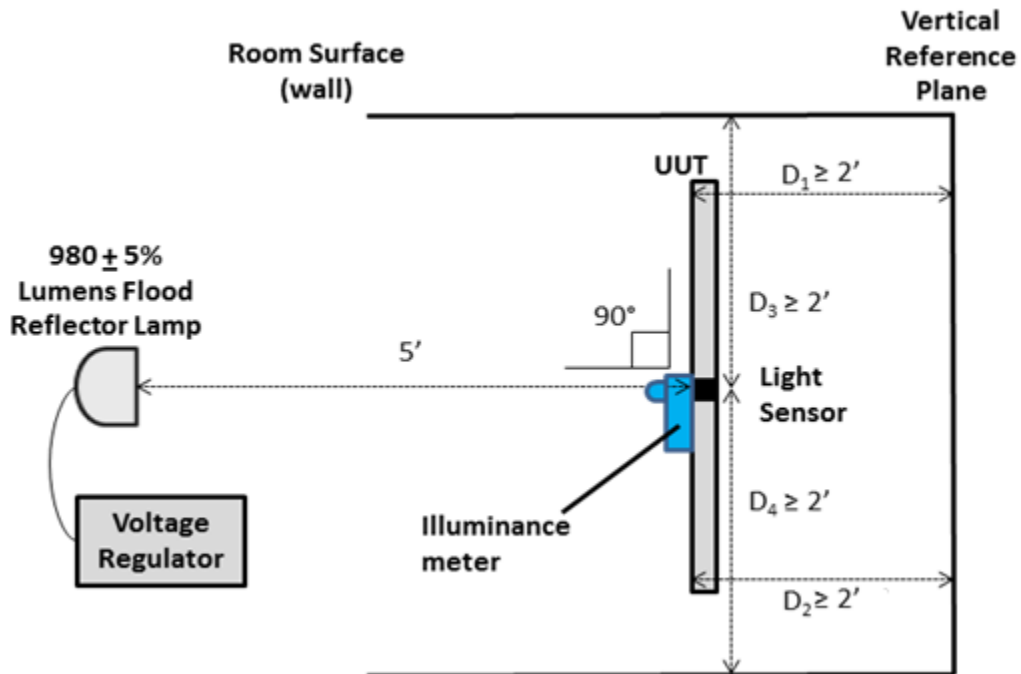
<sup>4</sup> IEEE 802 – Telecommunications and information exchange between systems – Local and metropolitan area networks – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

- 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.
- 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 two illuminance conditions—light and dark—to simulate daytime and nighttime conditions:
- 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 - Definitions<sup>5</sup>.
    - b) Rated Brightness: 980 ± 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 4 and Figure 5 provide more information on UUT and light source alignment.

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<sup>5</sup> <http://www.gpo.gov/fdsys/pkg/CFR-2011-title10-vol3/pdf/CFR-2011-title10-vol3-sec430-2.pdf>

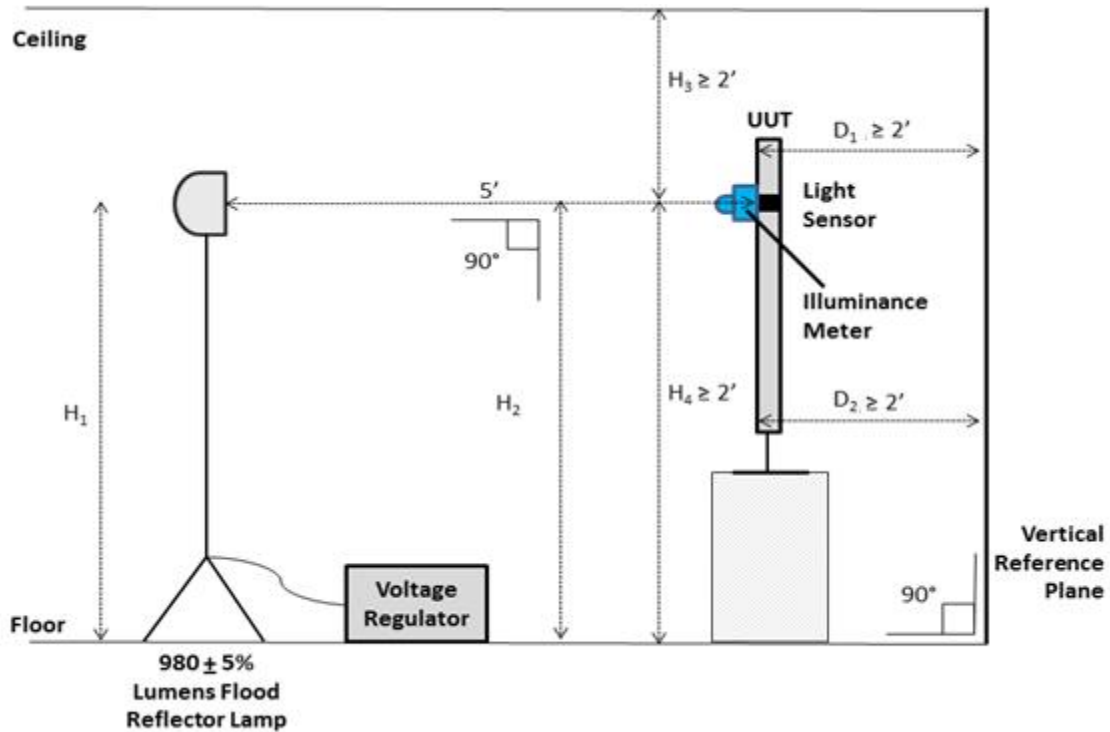




**Figure 4: Test Setup - Top View**

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  $300 \pm 9.0$  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  $10 \pm 1.0$  lux.

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

- 1) Products with an Occupancy Sensors 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  $\pm 2\%$  ( $\pm 2$  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 ( $\pm$ ) 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 cd/m<sup>2</sup>, 2% of 200 cd/m<sup>2</sup> is 4.0 cd/m<sup>2</sup>. The least significant digit is 0.1 cd/m<sup>2</sup>. "Two digits" implies 0.2 cd/m<sup>2</sup>. Thus, the displayed value would be  $200 \pm 4.2$  cd/m<sup>2</sup> (4 cd/m<sup>2</sup> + 0.2 cd/m<sup>2</sup>). 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  $\pm 1.0$  lux; and
  - b) At 300 lux, ambient lighting shall be within  $\pm 9.0$  lux.

## 5 TEST PROCEDURES FOR ALL PRODUCTS

### 5.1 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 AC load
  - 3) Connect the power meter to as described in Section 3.G).
  - 4) Connect an oscilloscope or other instrument to measure the duty cycle of the Control Pilot signal, the voltage at the VEM between "CP" and "Grnd" voltage measurement connections.

- 5) Connect the UUT input connection
  - a) For EVSE with an input cord, plug the EVSE input cord into the IMA receptacle.
  - b) For EVSE without an input cord, connect to the input terminals of the EVSE in accordance to Section 3.C)3).
  - c) For EVSE with multiple input cords, connect together all EVSE input cords in parallel and plug into the IMA receptacle.
- 6) Provide input power to the EVSE input connection(s).
- 7) Power on the UUT and perform initial system configuration, as applicable.
- 8) Ensure the UUT settings are in their as-shipped configuration, unless otherwise specified in this Test Method.
- 9) Report the test room ambient temperature, relative humidity, and the presence of ABC and occupancy sensors.

## 5.2 No Vehicle Mode (State A) Testing

- A) No Vehicle Mode testing shall be conducted for all products.
- B) Conduct the UUT preparation procedure in Section 5.1
- C) Verify the UUT output connector is unplugged from VEM.
- D) Measure and record UUT input power.
  - 1) For single-output EVSE:  $P = \frac{1}{T} \int_0^T v_{in}(t) \times i_{diff1}(t) dt$
  - 2) For multiple-output EVSE:  $P = \frac{\frac{1}{T} \int_0^T v_{in}(t) \times i_{diff1}(t) dt}{n}$ , where  $n$  is the number of outputs.
- E) Power shall be measured according to IEC 62301 Ed 2.0-2011; with the additional guidance in Section 4 of this document.

## 5.3 Partial On Mode (State B) and Idle Mode (State C) Testing

- A) Testing shall be conducted for two operational states of the J1772 interface (State B and State C)
- B) Conduct the UUT preparation procedure in Section 5.1
- C) 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.
- D) Conduct the following procedure to measure the UUT power consumption:
  - 1) State C<sup>6</sup>: Plug in all UUT output connection(s) to J1772 vehicle inlet on a corresponding number of VEM(s). Switch all VEMs to State C by closing switch S2. Measure and record:

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<sup>6</sup> This state represents a vehicle connected and ready to accept current.

a) For single-output EVSE:

i. UUT input power;  $P = \frac{1}{T} \int_0^T v_{in}(t) \times i_{diff1}(t) dt$

ii. UUT output RMS current  $I_{out2}$  (to verify zero output current).

b) For multiple-output EVSE:

i. UUT input power;  $P = \frac{\frac{1}{T} \int_0^T v_{in}(t) \times i_{diff1}(t) dt}{n}$ , where  $n$  is the number of outputs

ii. UUT output RMS current  $I_{out2}$  (to verify zero output current)

2) State B: Plug in the UUT output connection to J1772 vehicle inlet on the VEM. Connect all output cords to a corresponding number of VEMs. Verify S2 is open. Wait 2 minutes and then measure and record UUT input power:

a) For single-output EVSE:  $P = \frac{1}{T} \int_0^T v_{in}(t) \times i_{diff1}(t) dt$

b) For multiple-output EVSE:  $P = \frac{\frac{1}{T} \int_0^T v_{in}(t) \times i_{diff1}(t) dt}{n}$ , where  $n$  is the number of outputs.

E) Power shall be measured according to IEC 62301 Ed 2.0-2011; with the additional guidance in Section 4 of this document.

#### 5.4 Operation Mode (State C) Testing<sup>7</sup>

A) Testing shall be conducted with the VEM(s) in State C (S2 closed).

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) Determine the UUT available current.

1) Conduct the UUT preparation procedure in Section 5.1.

2) 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.

3) State C: Plug in the UUT output connection to J1772 vehicle inlet on VEM. Connect all output cords to a corresponding number of VEMs. If the UUT has multiple output cords, the outputs will be switched to State C sequentially. Close S2 in the VEM; for a multiple-output EVSE, switch that VEM to State C by closing switch S2, while keeping the remainder in State B (S2 open).

4) Calculate the available current from the measured Control Pilot Duty Cycle per Table 3.

**Table 3: Available Current Calculation from Control Pilot Duty Cycle (SAE J1772)**

Duty Cycle (%)	Available Current (A)
$10\% \leq \text{Duty Cycle} \leq 85\%$	% Duty Cycle x 0.6

<sup>7</sup> 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.

$85\% < \text{Duty Cycle} \leq 96\%$	$(\% \text{ Duty Cycle} - 64) \times 2.5$
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D) Warm-up

- 1) Ensure the unit is kept at ambient temperature for 30 minutes prior to the test.
- 2) Engage the AC load and draw full current output 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.

E) Measurement

- 1) After the 5-minute warm-up period, the technician shall monitor AC 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 1 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 AC 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;
  - b) RMS input voltage;
  - c) Power Factor (PF)
  - d) RMS output current for each output;
  - e) EVSE internal power loss
    - i. Input voltage measurement ( $V_{in}$ ) and the differential current measurement ( $I_{diff1}$ )
  - f) EVSE conductive power losses on Line 1
    - i. Differential voltage measurement of Line 1 ( $V_{diff1}$ ) and the input current measurement of Line 1 ( $I_{in1}$ )
  - g) EVSE conductive power losses on Line 2/N
    - i. Differential voltage measurement of Line 2/N ( $V_{diff2}$ ) and the output current measurement of Line 2/N ( $I_{out2}$ )
  - h) For single-output EVSE, Input Power, Output Power and Total Power Loss (combinations of the power loss measurements 5.4.E)2)e), f), and g)):

$$P_{INPUT} = \frac{1}{T} \int_0^T i_{diff1}(t) \times v_{in}(t) dt$$

$$P_{OUTPUT} = \frac{1}{T} \int_0^T (i_{out2}(t) \times v_{diff2}(t) - i_{in1}(t) \times v_{diff1}(t)) dt$$

$$P_{loss} = P_{INPUT} - P_{OUTPUT}$$

- i) For multiple-output EVSE, Total Power Loss:
  - i. Measure input and output power for each EVSE output (combination of the power loss measurements 5.4.E)2)e), f), and g), where i is the number of the output under test:

$$P_{INPUT_i} = \frac{1}{T} \int_0^T i_{diff1i}(t) \times v_{in}(t) dt$$

$$P_{OUTPUT_i} = \frac{1}{T} \int_0^T (i_{out2}(t) \times v_{diff2}(t) - i_{in1}(t) \times v_{diff1}(t)) dt$$

- ii. Switch the VEM under test back to State B by opening S2.
- iii. Connect the output power meter to the next VEM. And close S2 on the VEM putting it in State C.
- iv. Repeat steps i through iii, above, until the input and output power from each output,  $P_{INPUT_i}$  and  $P_{OUTPUT_i}$  have been measured.
- v. Sum the output power results for each output and divide by the number of outputs,  $n$ .  

$$P_{OUTPUT} = \frac{\sum_{i=1}^n P_{OUTPUT_i}}{n}$$
- vi. Sum the input power results for each output and divide by the number of outputs,  $n$ . Then, after conducting the Partial On test, in Section 5.3. above, multiply the measured Partial On power by  $n-1$  and subtract from the input power sum, as shown below:

$$P_{INPUT} = \frac{\sum_{i=1}^n P_{INPUT_i}}{n} - (n-1) \times \frac{\frac{1}{T} \int_0^T v_{in}(t) \times i_{diff1}(t) dt}{n} \Bigg|_{\text{Partial On}}$$

$$P_{loss} = P_{INPUT} - P_{OUTPUT}$$

- 3) Repeat for all loading conditions in Table 4 that are less than or equal to the full current output capability of the UUT, in sequence from Loading Condition 2 to Loading Condition 4.
- 4) Measurements at subsequent loading conditions shall be conducted under the 5-minute stability guidelines in Section 5.4.E)1), above.

**Table 4: Loading Conditions for UUT**

	Test Condition Current (A)	Example for 80 A capable UUT	Example for 32 A capable UUT	Example for 16 A capable UUT
Loading Condition 1	Available Current (determined in Section 5.4.C), above) $\pm 2\%$ .	80.0 A	32.0 A	16.0 A
Loading Condition 2	30.0 A $\pm 0.6$ A	30.0 A	30.0 A	Do not test
Loading Condition 3	15.0 A $\pm 0.3$ A	15.0 A	15.0 A	15.0 A
Loading Condition 4	4.00 A $\pm 0.1$ A	4.0 A	4.0 A	4.0 A

## **5.5 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 4.1.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.