ENERGY STAR® Program Requirements
Product Specification for
Electric Vehicle Supply Equipment

Draft 3 Test Method
Rev. March-2016

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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, 5.3, 5.4, and 5.5 shall be performed on all products.
- The test procedures in Section 5.2 shall be performed on products that have an APD timer.
- The test procedures in Section 5.6 shall be performed on products with network connectivity.

Note: EPA has moved the Definitions, Scope, and Connected Functionality Criteria (for those products with grid communication capabilities) from the Test Method and into the Draft 1 Specification. These items will live in the Specification moving forward.

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.

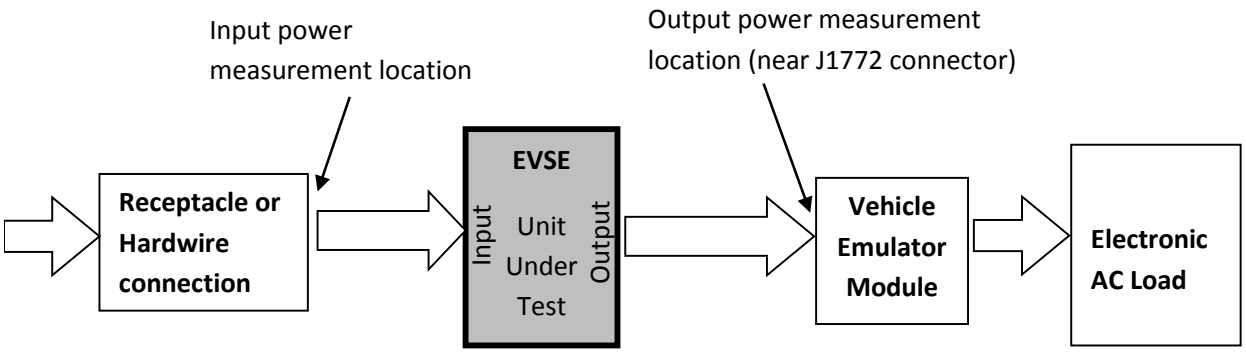

Figure 1a: Schematic of test setup connection

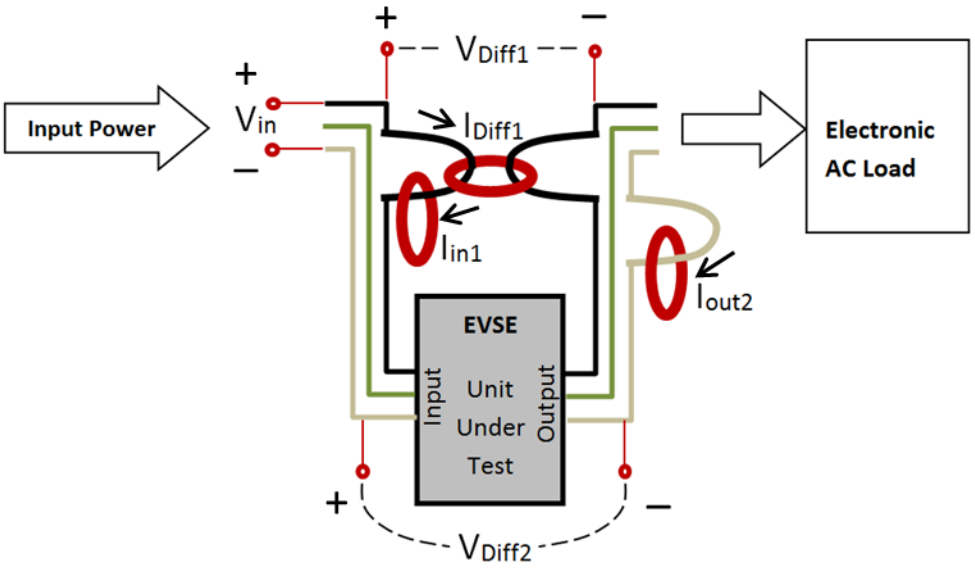

Figure 1b: Schematic of test setup connection

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)

Note: The accuracy of the power measurement has been significantly improved with the new testing setup outlined in Figure 1a and Figure 1b. This new procedure measures power indirectly by multiplying differential current by input voltage and differential voltage by input and output current, thereby eliminating instances when meter inaccuracies are multiplied by both a large current and large voltage. EPA believes that this revised approach will result in acceptable accuracy.

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

Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency Tolerance
+/- 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 an input plug and cord, the corresponding receptacle will be used to provide power to the input plug of the EVSE. An Input Measurement Apparatus (IMA) is used with EVSE that are provided with an input plug and cord. The IMA enables input current and input voltage measurements of EVSE without the need to modify the EVSE input cord.

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

   b) Current Measurements shall be measured 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 measured at the hardwire connection location at the input terminal of the EVSE.

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

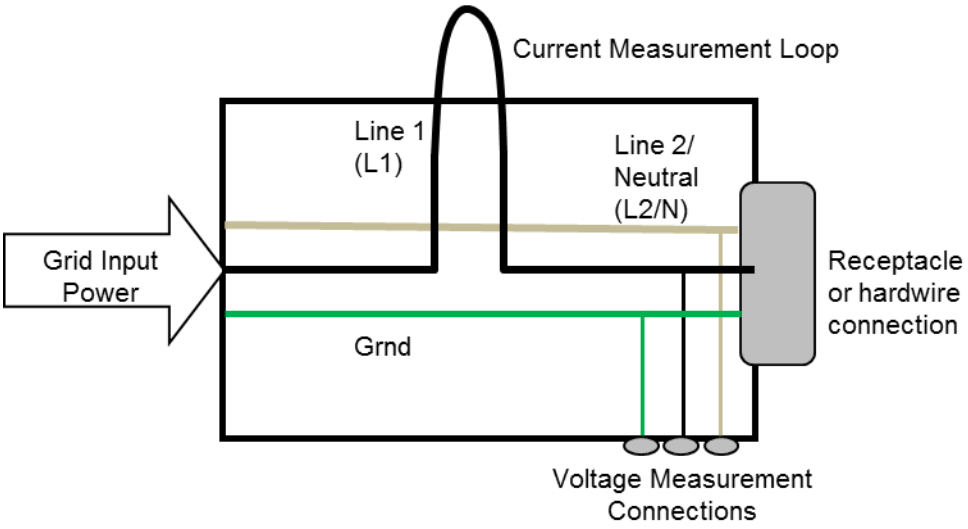

Figure 2: Schematic of Input Measurement Apparatus (IMA)[1]

Note: EPA has updated Figure 2 by adding a third voltage measurement connection to account for the update to the test procedure as described in Figure 1b.

D) Ambient Temperature: Ambient temperature shall remain at 25°C ± 5°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 consisting of an AC load bank 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. 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.

Note: For EVSE with multiple charge cable options, EPA intends to permit an approach that includes evaluation of construction and wire gauge, testing only the longest available cable, as long as others are of the same gauge.

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.

c) S1 is a switch which is used to enable control pilot state “C”.

d) S2 is a switch which is used to enable control pilot state “D”.

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

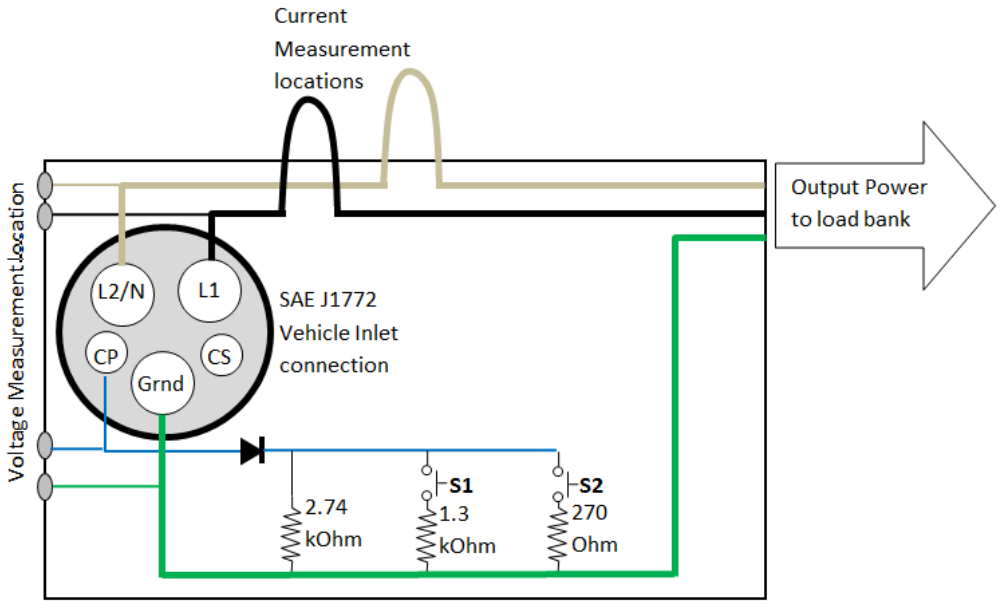

Figure 3: Schematic of Vehicle Emulator Module (VEM)[2]

Note: EPA has updated Figure 3 by adding a second current measurement connection to account for the update to the test procedure as described in Figure 1b.

2) AC Load: The AC load bank 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})

Note: EPA has updated the procedure for setting up measurement locations as it relates to the new procedure for calculating power loss.

2) Crest Factor:

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

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

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

Note: EPA has reintroduced the power factor and apparent power measurements to the test method. Stakeholders provided feedback that understanding the power factor of an EVSE could provide valuable insight regarding any potential power losses. Stakeholders also indicated that reporting the power factor would not be overly burdensome because power meters typically already measure power factor during power measurement. Therefore, EPA is re-introducing the definition of power factor and proposes requiring the manufacturers to report the power factor when certifying their EVSE to ENERGY STAR. EPA has also added cable length and cable gauge to the measurements section, as these factors will affect operation mode performance, to inform future versions of the specification.

h) Frequency (Hz).

B) Illuminance Meter Accuracy:

1) All luminance and 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 4.1.C)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.

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[3]);

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)[4], 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.

[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

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) Room Illuminance Conditions for Products with Automatic Brightness Control (ABC) Enabled by Default: All products with ABC enabled by default shall be tested in a 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[5].

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.

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

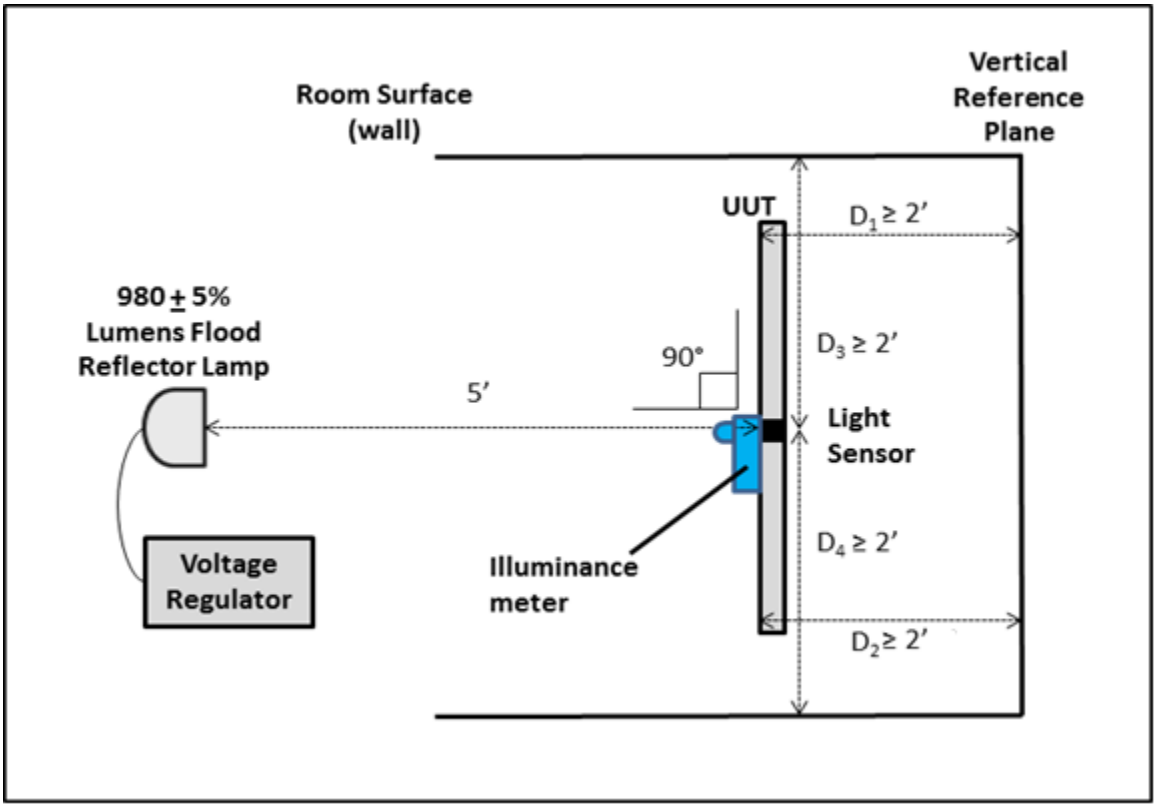

Figure 4: Test Setup - Top View

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

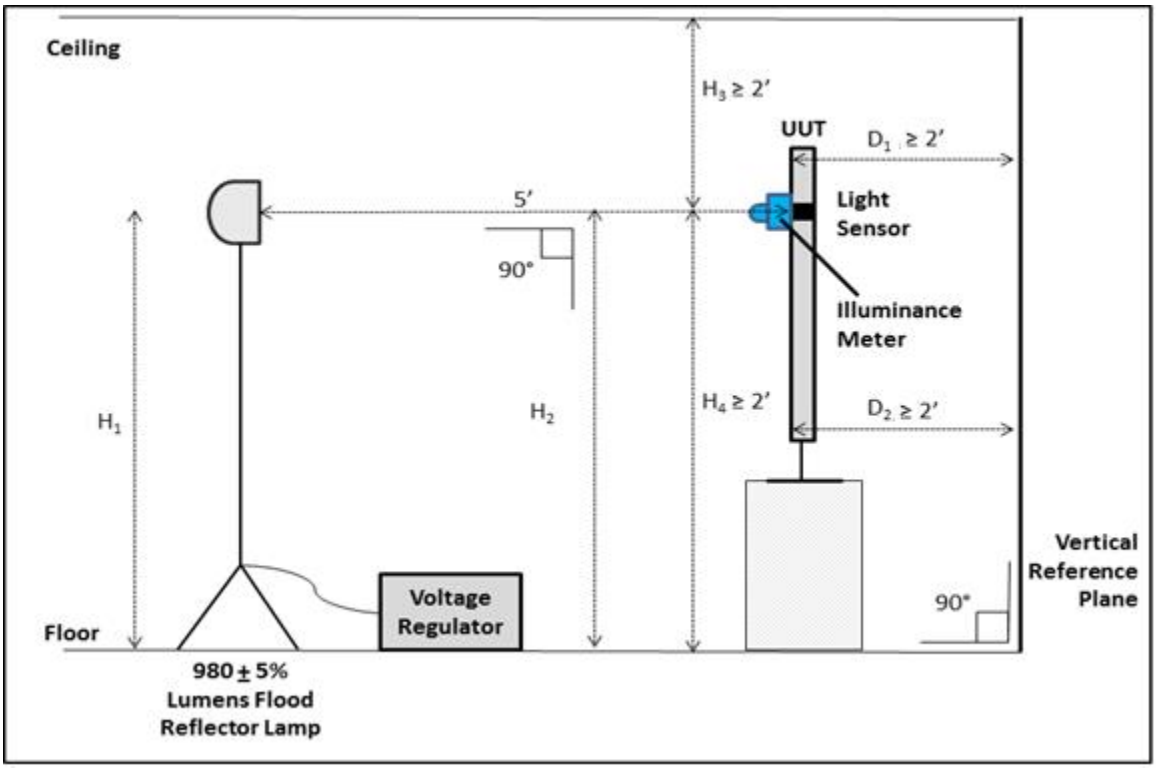

Figure 5: Test Setup - Side View

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

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 ± 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 ± 1.0 lux.

Note: EPA has lowered the dark light condition to 10 ± 1.0 lux to align with a study on Lighting for Parking Facilities that was done by the Illuminating Engineering Society that recommends 10 lux for concrete parking facilities during normal operating hours.

D) 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.

E) Measurement Accuracy:

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

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

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.

Note: EPA has removed the references to where measurements should be taken as they have been described in Section 3.G. They have been slightly altered to account for the new method of calculating power loss.

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.

6) Provide input power to the EVSE input connection.

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 AC RMS input voltage and frequency.

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

5.2 Auto Power Down (APD) Function

A) APD testing shall be conducted only for products that have an APD timer.

B) Conduct the UUT preparation procedure in Section 5.1.

C) Ensure the APD timing is set to the default value.

D) Ensure any demand-response functionality is disabled.

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

E) State C: Plug in the UUT output connection to J1772 vehicle inlet on VEM. Connect S1 in the VEM.

F) Begin measuring the elapsed time to APD after the product ceases performance of all Primary Function.

G) Measure and record the average power before APD over a 2 minute period.

H) Allow the UUT to automatically power-down.

I) Verify that the device is in the expected APD low-power state and record the time to APD.

J) Measure and record the average power after APD over a 2 minute period.

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

L) Repeat steps A through K for States A and B1

Note: In response to stakeholder feedback that an APD response may differ if the EVSE is connected to the vehicle or not, EPA has added an APD test to account for any differentiation in power consumption.

5.3 Off Mode Testing

A) Off Mode testing shall be conducted only for products that have a manual off switch that disables secondary functions.

B) Conduct the UUT preparation procedure in Section 5.1

C) Place the UUT in Off Mode using the manual switch.

D) Measure and record UUT input power. $P = I_{diff1} \times V_{in}$

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 Partial On Mode and Idle Mode Testing

A) Testing shall be conducted for three operational states of the UUT (State A through 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 A: Verify the UUT output connector is unplugged from VEM. Measure and record

a) UUT input power. $P = I_{diff1} \times V_{in}$

2) State B[6]: Plug in the UUT output connection to J1772 vehicle inlet on the VEM and verify S1 is open. Measure and record:

a) UUT input power. $P = I_{diff1} \times V_{in}$

3) State C[7]: Plug in the UUT output connection to J1772 vehicle inlet on VEM. Connect S1 in the VEM. Measure and record:

a) UUT input power; $P = I_{diff1} \times V_{in}$ and

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

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

5.5 Operation Mode Testing[8]

A) Testing shall be conducted with the VEM in State C (S1 connected). On Mode Testing will be repeated with the VEM in State D (S2 connected) only for EVSE that operate a ventilation fan as required by a vehicle in State D. If the UUT does not operate a ventilation fan, testing with the VEM in State D is not required.

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) State C: Plug in the UUT output connection to J1772 vehicle inlet on VEM. Connect S1 in the VEM.

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[6] This state represents a vehicle connected but not ready to accept current.

[7] This state represents a vehicle connected and 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.

3) 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% ≤ Duty Cycle ≤ 85%	% Duty Cycle x 0.6
85% < Duty Cycle ≤ 96%	(% Duty Cycle – 64) x 2.5

Note: EPA continues to propose that the control pilot duty cycle be used to calculate the available current. Based on testing data, there is a lack of difference between the nameplate and pilot (less than 0.5% on average). In addition, reading the control pilot is more representative of real-world conditions.

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.

Note: EPA has shortened the length of the warm-up period to 5 minutes to reduce testing time but will still require that the unit be kept at ambient temperature for 30 minutes prior to testing. This will prevent any changes in resistance due to temperature.

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)

Note: EPA has reintroduced the power factor measurement into the test method.

d) RMS output current;

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) Total Power Loss (sum of the power loss measurements 5.5.E.2.e, f, and g):

$$P_{loss} = I_{diff1} \times V_{in} + I_{in1} \times V_{diff1} - I_{out2} \times V_{diff2}$$

Note: EPA has added an equation for calculating power loss with the change in the test procedure that will result in significant improvements in accuracy.

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 step 1), above.

Note: EPA has combined all the loading and measurement instructions in this section and placed them following the warm-up procedure.

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 5.5.C), above) ± 2%.	80.0 A	32.0 A	16.0 A
Loading Condition 2	30.0 A ±0.6 A	30.0 A	30.0 A	Do not test
Loading Condition 3	15.0 A ±0.3 A	15.0 A	15.0 A	15.0 A
Loading Condition 4	4.00 A ±0.1A	4.0 A	4.0 A	4.0 A

5.6 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 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 4.1B)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.

Note: EPA has moved the reference to Connected Functionality from the Test Method into the Draft 1 Specification. These items will live in the Specification moving forward.