



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

Final Draft Test Method Rev. August-2016

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.

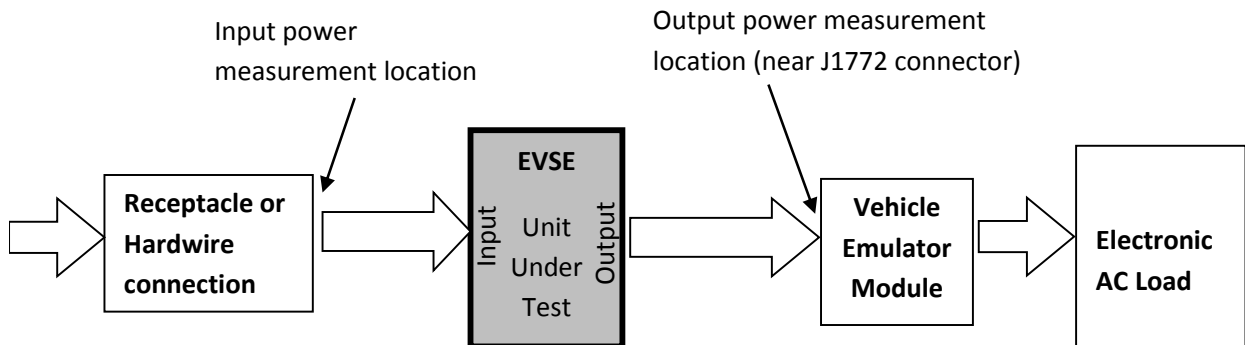
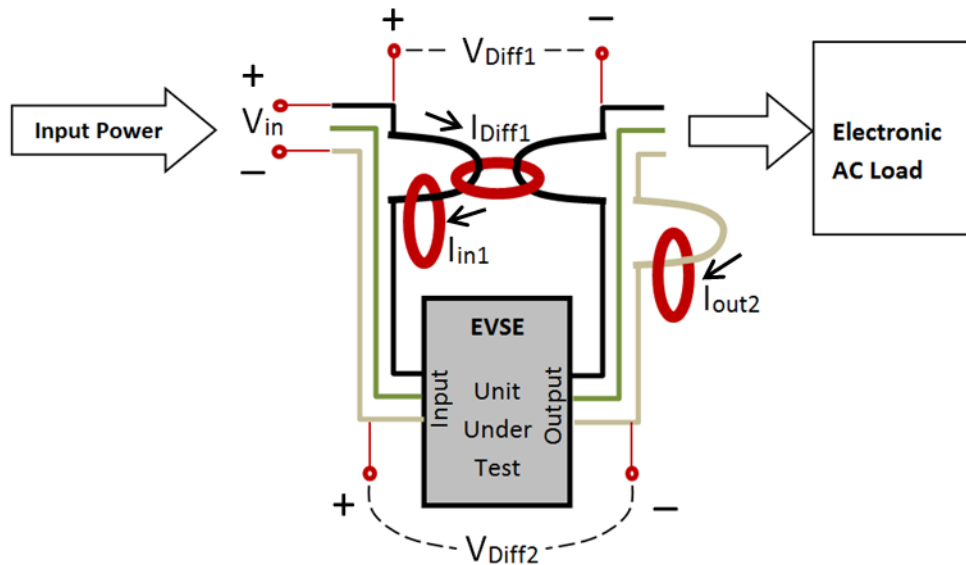


Figure 1a: Schematic of test setup connection



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Figure 1b: Schematic of test setup connection

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

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- 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)

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

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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.

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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.

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3) The voltage and frequency tolerance shall be as specified in Table 2.

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Table 1: Input Supply Requirements

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

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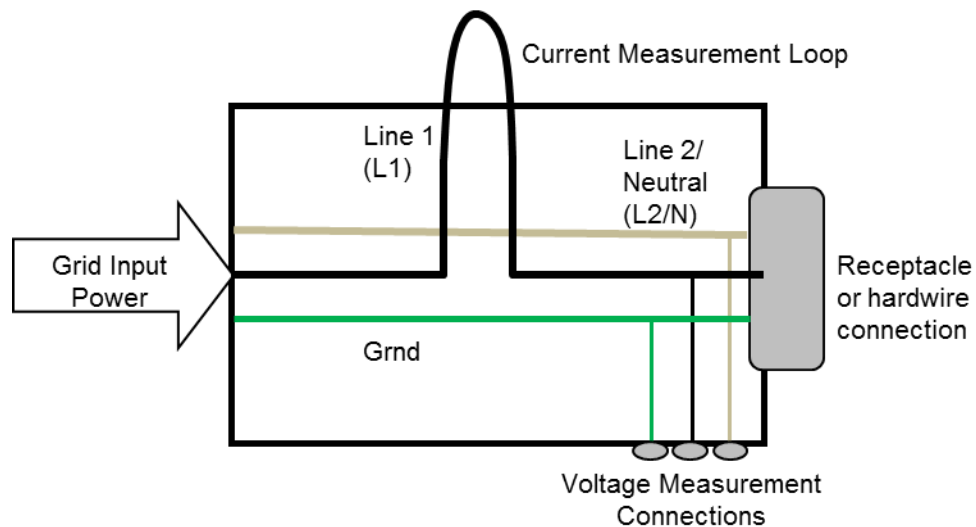
Table 2: Input Power Tolerances

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

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45 C) Input Power Measurements:

- 46 1) Cables: All power cables for the test shall be the default provided by the manufacturer
- 47 2) For EVSE equipped with an input plug and cord, the corresponding receptacle will be used to
- 48 provide power to the input plug of the EVSE. An Input Measurement Apparatus (IMA) is used with
- 49 EVSE that are provided with an input plug and cord. The IMA enables input current and input
- 50 voltage measurements of EVSE without the need to modify the EVSE input cord.
- 51 a) Voltage Measurements shall be measured at the wiring terminals of the receptacle in the IMA
- 52 providing power to the EVSE input plug.
- 53 b) Current Measurements shall be measured on the wiring of the IMA connected to receptacle
- 54 terminals.
- 55 3) For EVSE intended for hardwire connection, the UUT's input power shall then be connected to
- 56 AC Input Power source with cables and optional connectors that are rated for the voltage and
- 57 current levels that will be encountered during testing.
- 58 a) Voltage Measurements shall be measured at the hardwire connection location at the input
- 59 terminal of the EVSE.
- 60 b) Current Measurements shall be measured on the wiring to the EVSE hardwire connection.



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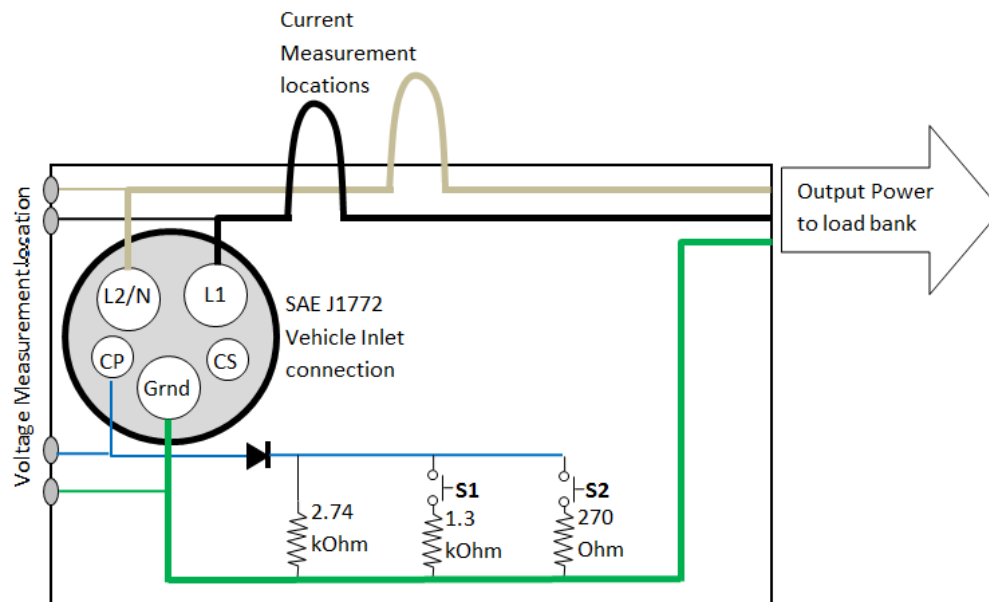
Figure 2: Schematic of Input Measurement Apparatus (IMA)¹

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- 63 D) Ambient Temperature: Ambient temperature shall remain at 25°C ± 5°C for the duration of the test.

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

- 64 E) Relative Humidity: Relative humidity shall remain between 10% and 80% for the duration of the test.
- 65 F) Test Load: A test load consisting of an AC load bank shall be connected to the EVSE output in lieu of
- 66 a vehicle.
- 67 1) Vehicle Emulator Module (VEM): A VEM allows current and voltage measurements of the UUT
- 68 output without modifying or altering the UUT output cable. Figure 3 shows an example schematic
- 69 of the VEM.
- 70 a) Output Power measurement: Insulated current conductor loops or current measurement
- 71 shunts as well as voltage measurement connections shall be used to measure the UUT
- 72 output current and voltage.
- 73 i. If there are multiple output cable options for a given model, the longest available cable
- 74 shall be used for the test.
- 75 b) Output Coupler: The SAE J1772 interface shall be used to connect between the UUT and
- 76 VEM. If the UUT does not have an SAE J1772 output coupler, an adapter shall be provided
- 77 by the manufacturer.
- 78 c) S1 is a switch which is used to enable control pilot state “C”.
- 79 d) S2 is a switch which is used to enable control pilot state “D”.



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81 **Figure 3: Schematic of Vehicle Emulator Module (VEM)²**

- 82 2) AC Load: The AC load bank shall possess the following capabilities
- 83 a) Sink AC current up to the rated RMS current of the UUT;
- 84 b) Voltage range within the Level of the UUT (Level 1 or Level 2); and
- 85 c) Controllable RMS current levels capable of achieving current levels detailed in Table 4.
- 86 G) Power Meter: Power meters shall possess the following attributes:

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

- 87 1) Number of Channels:
- 88 a) One channel shall be set up to measure the AC power of the internal components of the UUT
- 89 i. Input voltage measurement (V_{in}) and the differential current measurement (I_{diff1})
- 90 b) One channel shall be set up to measure power loss across the EVSE on Line 1
- 91 ii. Differential voltage measurement of Line 1 (V_{diff1}) and the Input current measurement of
- 92 Line 1 (I_{in1})
- 93 b) One channel shall be set up to measure power loss across the EVSE on Line 2/N
- 94 ii. Differential voltage measurement of Line 2/N (V_{diff2}) and the Output current measurement
- 95 of Line 2/N (I_{out2})
- 96 2) Crest Factor:
- 97 a) An available current crest factor of 3 or more at its rated range value; and
- 98 b) Lower bound on the current range of 10 mA or less.
- 99 3) Minimum Frequency Response: 3.0 kHz
- 100 4) Minimum Resolution:
- 101 a) 0.01 W for measurement values less than 10 W;
- 102 b) 0.1 W for measurement values from 10 W to 100 W; and
- 103 c) 1.0 W for measurement values greater than 100 W.
- 104 5) Accuracy: +/- 0.1% of reading PLUS +/- 0.1% of full scale
- 105 6) Measurements and Calculations:
- 106 a) Cable Length (ft.);
- 107 b) Cable Gauge (AWG);
- 108 c) Power Factor (PF)
- 109 d) Apparent Power (S)
- 110 e) Voltage (RMS);
- 111 f) Current (RMS);
- 112 g) Average Power (W); and
- 113 h) Frequency (Hz).

114 B) Illuminance Meter Accuracy:

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

117 Note: The overall accuracy of a meter is found by taking (\pm) the absolute sum of 2% of the

118 measurement and a 2 digit tolerance of the displayed value least significant digit. For example, if a

119 meter displays "200.0" when measuring an illuminance of 200 lx, 2% of 200 lx is 4.0 lx. The least

120 significant digit is 0.1 lx. "Two digits" implies 0.2 lx. Thus, the displayed value would be 200 ± 4.2 lx (4

121 lx + 0.2 lx). The accuracy is specific to the illuminance meter and shall not be considered as tolerance

122 during actual light measurements. Light measurements shall be within the tolerance specified in

123 4.1.C)3).

124 **4 TEST CONDUCT**

125 **4.1 Guidance for Implementation of the EVSE Test Procedure**

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

128 1) The UUT shall be mounted per the manufacturer's installation instructions. If no manufacturer
129 instructions are provided, the UUT shall be tested on a thermally non-conductive surface.

130 B) UUT Configuration and Control:

131 1) Network Connection Capabilities:

132 a) Verify the UUT has network connection capabilities:

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

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

137 2) Peripherals and Network Connections:

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

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

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

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

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

150 i. Wi-Fi (Institution of Electrical and Electronics Engineers - IEEE 802.11- 2007³);

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

154 iii. Cellular modem; or

155 iv. Other.

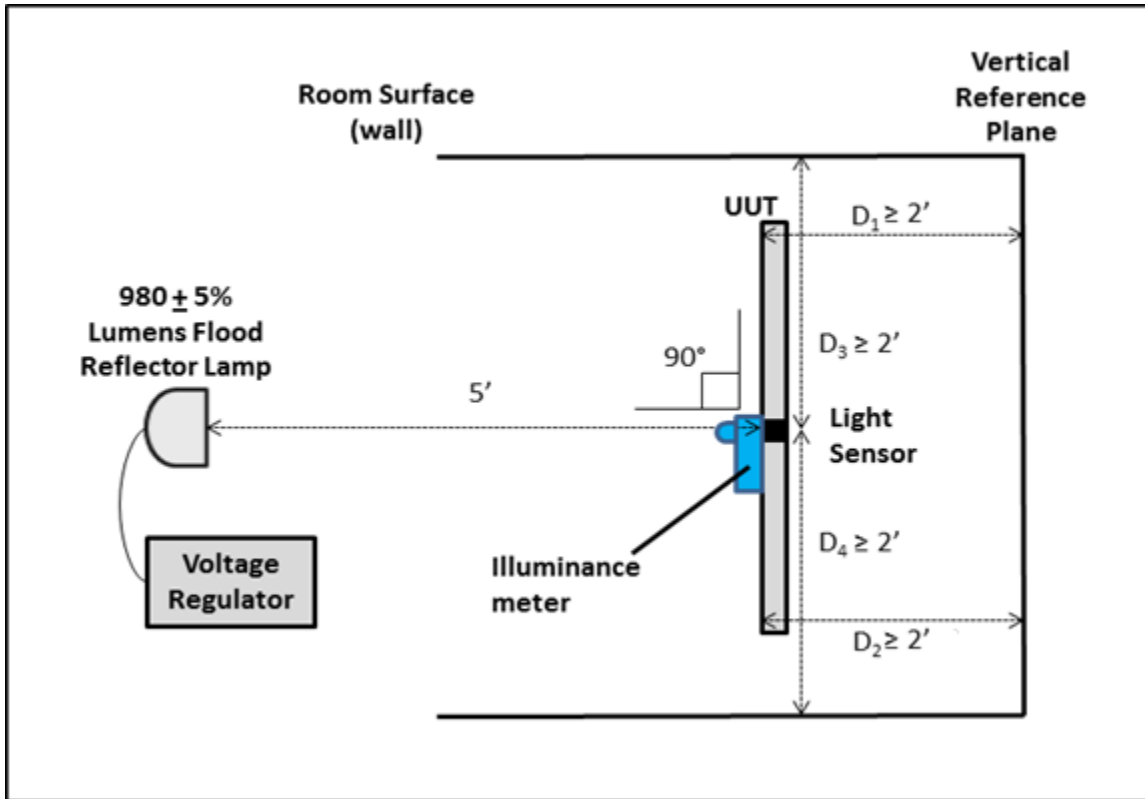
156 d) The tester shall configure the address layer of the protocol, taking note of the following:

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

- 157 i. Internet Protocol (IP) IP v6 has Neighbor Discovery and will generally configure a
158 limited, non-routable connection automatically.
- 159 ii. IP can be configured manually or using Dynamic Host Configuration Protocol
160 (DHCP) with an address in the 192.168.1.x Network Address Translation (NAT)
161 address space if the UUT does not behave normally when autoIP is used. The
162 network shall be configured to support the NAT address space and/or autoIP.
- 163 e) The UUT shall maintain this live connection to the network for the duration of testing,
164 disregarding any brief lapses, (e.g., when transitioning between link speeds).
- 165 f) Ensure there is a connection to the Wide Area Network if required in the manufacturer's
166 instructions.
- 167 g) If the UUT needs to install any software updates, wait until these updates have occurred;
168 otherwise, if it will operate without updates, skip these updates.
- 169 h) In the case of a UUT that has no data/network capabilities, the UUT shall be tested as-
170 shipped.
- 171 C) Room Illuminance Conditions for Products with Automatic Brightness Control (ABC) Enabled by
172 Default: All products with ABC enabled by default shall be tested in a two illuminance conditions—
173 light and dark—to simulate daytime and nighttime conditions:
- 174 1) Lamp Type:
- 175 a) Standard spectrum halogen flood reflector lamp. The lamp shall not meet the definition of
176 "Modified spectrum" as defined in 10 CFR 430.2 - Definitions⁵.
- 177 b) Rated Brightness: 980 ± 5% lumens.
- 178 2) Light Source Alignment For Testing Products With ABC Enabled By Default:
- 179 a) There shall be no obstructions between the lamp and the UUT's Automatic Brightness
180 Control (ABC) sensor (e.g., diffusing media, frosted lamp covers, etc.).
- 181 b) The center of the lamp shall be placed at a distance of 5 feet from the center of the ABC
182 sensor.
- 183 c) The center of the lamp shall be aligned at a horizontal angle of 0° with respect to the center
184 of the UUT's ABC sensor.
- 185 d) The center of the lamp shall be aligned at a height equal to the center of the UUT's ABC
186 sensor with respect to the floor (i.e. the light source shall be placed at a vertical angle of 0°
187 with respect to the center of the UUT's ABC sensor).
- 188 e) No test room surface (i.e., floor, ceiling, and wall) shall be within 2 feet of the center of the
189 UUT's ABC Sensor.
- 190 f) Illuminance values shall be obtained by varying the input voltage of the lamp.
- 191 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>



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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

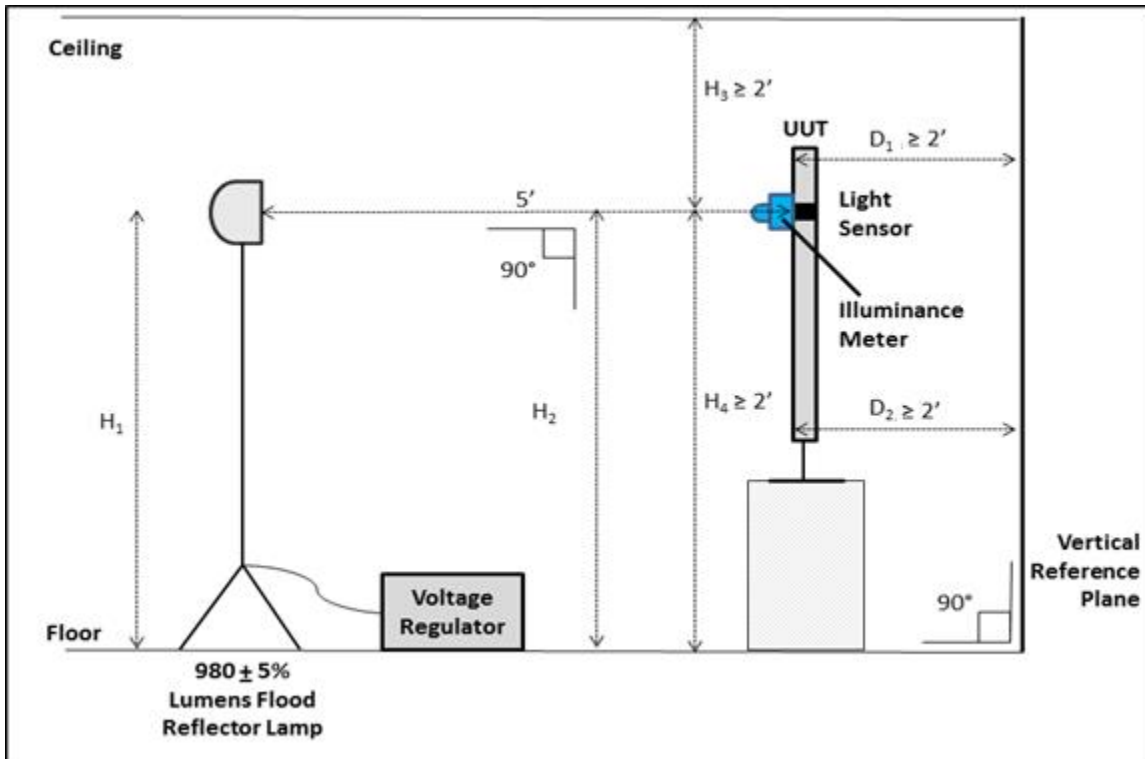


Figure 5: Test Setup - Side View

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.

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

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

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

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

221 E) Measurement Accuracy:

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

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

226 **5 TEST PROCEDURES FOR ALL PRODUCTS**

227 **5.1 UUT Preparation**

228 A) Prior to the start of testing, the UUT shall be initialized as follows:

229 1) Set up the UUT per the instructions in the supplied product manual.

230 2) Verify the VEM output is connected to the AC load

231 3) Connect the power meter to as described in Section 3.G).

232 4) Connect an oscilloscope or other instrument to measure the duty cycle of the Control Pilot signal,
233 the voltage at the VEM between "CP" and "Grnd" voltage measurement connections.

234 5) Connect the UUT input connection

235 a) For EVSE with an input cord, plug the EVSE input cord into the IMA receptacle.

236 b) For EVSE without an input cord, connect to the input terminals of the EVSE in accordance to
237 Section 3.C)3).

238 6) Provide input power to the EVSE input connection.

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

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

242 9) Report the AC RMS input voltage and frequency.

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

245 **Note:** EPA received substantial stakeholder feedback that an EVSE can only power down to a lower
246 power state after the EV has released the connection to the EVSE such that current no longer passes
247 through. Therefore, EPA proposes to remove APD as a requirement. Instead, EPA proposes a 2 minute
248 delay before testing the maximum Partial On Mode power to ensure that the UUT has already
249 transitioned to this state. EPA believes that an EVSE is capable of powering down any unnecessary
250 features during this 2 minute delay period thereby capturing any potential power management
251 capabilities. With this approach, EPA continues to incentivize EVSE power management and also
252 provides manufacturers with flexibility to decide which feature(s) will be turned off or how EVSE can enter
253 lower power state during this delay period.

254 **5.2 Off Mode (State A) Testing**

- 255 A) Off Mode testing shall be conducted only for products that have a manual off switch that disables
256 secondary functions.
- 257 B) Conduct the UUT preparation procedure in Section 5.1
- 258 C) Verify the UUT output connector is unplugged from VEM.

259 **Note:** As a result of stakeholder feedback, EPA altered the definitions of the EVSE modes to provide
260 clarity and additional alignment with the SAE standards. In addition, EPA has specified here that the UUT
261 should be unplugged from the VEM in order to conduct the Off Mode testing as the majority of models do
262 not appear to have a manual switch. EPA would appreciate stakeholder feedback on this clarification.

- 263 D) Measure and record UUT input power. $P = I_{diff1} \times V_{in}$
- 264 E) Power shall be measured according to IEC 62301 Ed 2.0-2011; with the additional guidance in
265 Section 4 of this document.

266 **5.3 Partial On Mode (State B) and Idle Mode (State C) Testing**

- 267 A) Testing shall be conducted for two operational states of the J1772 interface (State B and State C)
- 268 B) Conduct the UUT preparation procedure in Section 5.1
- 269 C) Ensure any demand-response functionality or timer is disabled.
- 270 1) If demand-response functionality or timer cannot be disabled and a demand-response or timer
271 function occurs during a test, the results from the test shall be replaced with results from a
272 substitute test.
- 273 D) Conduct the following procedure to measure the UUT power consumption:
- 274 1) State C⁶: Plug in the UUT output connection to J1772 vehicle inlet on VEM. Connect S1 in the
275 VEM. Measure and record:
- 276 a) UUT input power; $P = I_{diff1} \times V_{in}$ and
- 277 b) UUT output RMS current I_{out2} (to verify zero output current).
- 278 2) State B: Plug in the UUT output connection to J1772 vehicle inlet on the VEM and verify S1 is
279 open. Wait 2 minutes and then measure and record

⁶ This state represents a vehicle connected and ready to accept current.

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

281 **Note:** EPA altered the definitions of the EVSE modes to provide clarity and additional alignment with the
282 SAE standards.

283 EPA has switched the order to test State C prior to State B and has added a 2 minute delay to begin after
284 the unit has transitioned from State C to State B. EPA believes that a unit will be able to power down any
285 unnecessary features during this 2 minute delay period.

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

288 5.4 Operation Mode (State C) Testing⁷

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

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

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

297 C) Determine the UUT available current.

298 1) Conduct the UUT preparation procedure in Section 5.1.

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

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

302 **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
$85\% < \text{Duty Cycle} \leq 96\%$	(% Duty Cycle - 64) x 2.5

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304 D) Warm-up
305 1) Ensure the unit is kept at ambient temperature for 30 minutes prior to the test.
306 2) Engage the AC load and draw full current output for 5 minutes or more.
307 3) Only one warm-up period of 5 minutes is required for each unit under test at the beginning of the
308 test procedure.

309 E) Measurement

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.

- 310 1) After the 5-minute warm-up period, the technician shall monitor AC input current for a period of 5
311 minutes to assess the stability of the unit under test.
- 312 a) If the input current level does not drift by more than 1 percent from the maximum value
313 observed over the 5-minute period, the unit under test can be considered stable and
314 measurements can be recorded at the end of the 5-minute period.
- 315 b) If AC input current is not stable over a 5-minute period, the technician shall follow the
316 guidelines established by IEC Standard 62301 for measuring average power or accumulated
317 energy over time for both input and output.
- 318 2) The following measurements and calculated values shall be recorded after the 5-minute
319 stabilization period:
- 320 a) RMS input current;
- 321 b) RMS input voltage;
- 322 c) Power Factor (PF)
- 323 d) RMS output current;
- 324 e) EVSE internal power loss
- 325 i. Input voltage measurement (V_{in}) and the differential current measurement (I_{diff1})
- 326 f) EVSE conductive power losses on Line 1
- 327 i. Differential voltage measurement of Line 1 (V_{diff1}) and the Input current measurement of
328 Line 1 (I_{in1})
- 329 g) EVSE conductive power losses on Line 2/N
- 330 i. Differential voltage measurement of Line 2/N (V_{diff2}) and the Output current measurement
331 of Line 2/N (I_{out2})
- 332 h) Total Power Loss (sum of the power loss measurements 5.5.E.2.e, f, and g):
- 333
$$P_{loss} = I_{diff1} \times V_{in} + I_{in1} \times V_{diff1} - I_{out2} \times V_{diff2}$$
- 334
- 335 3) Repeat for all loading conditions in Table 4 that are less than or equal to the full current output
336 capability of the UUT, in sequence from Loading Condition 2 to Loading Condition 4.
- 337 4) Measurements at subsequent loading conditions shall be conducted under the 5-minute stability
338 guidelines in step 1), above.

339

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 0.1A	4.0 A	4.0 A	4.0 A

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341 **5.5 Full Network Connectivity Testing**

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

- 346
- 347 1) The UUT shall be connected to a network per Section 4.1B)2) of this test method prior to the test;
348 and
 - 349 2) The UUT shall be placed into Partial On Mode in place of Standby-active, Low Mode.