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TITLE OF THE CD (English):  
OIML G xx  
**Electrical Vehicle Supply Equipment**  
Part 1: Metrological and Technical Requirements  
Part 2: Metrological controls and performance tests

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## Explanatory Note

As a result of the transition from fossil fuels to sustainable forms of energy, worldwide developments in the area of charging electrical vehicles (EVs) are proceeding at a rapid pace. In this newly developing market, it is important that trading parties have confidence that the amount of energy transferred is measured fairly and accurately. Regulators in various individual economies have started or are starting initiatives to develop national or regional metrology regulation for Electrical Vehicle Supply Equipment (EVSE), of which the requirements are not always mutually exchangeable.

The need for international guidance on metrology for EVSE was already agreed upon by the CIML at their 51<sup>st</sup> meeting in 2016 in Strasbourg, where they decided on the mandate to revise R 46:2012 “ACTIVE ENERGY ELECTRICITY METERS”. Recommendations for EVSE metrology were initially foreseen to be embedded in the next version of R 46. By 2021, however, it became apparent that the needs of the EVSE market and of regulators were more urgent than what could be met by the timeline expected for the publication of the revised R 46. Initial work on an international document on EVSE requirements and test procedures was done as part of the revision process for R 46. This effort was subsequently split off into a separate project group, established in October 2021. The existence of the new project group allowed the development of a self-contained OIML publication for EVSE, separate from R 46, and which could be published on a faster timeline than that of the ongoing revision of R 46. While there are obvious similarities between ‘traditional’ (utility type) electricity metering and charging EVs, there are also profound differences. This separate OIML publication for EVSE allows for a clear treatment of the unique aspects of EV charging, such as the direct sales nature of transactions, means of conveying the measurement result, and typical progressions of current levels over time.

Initially this new project group determined that the most expedient way to introduce guidance related to EVSE is to develop a Guide document based on many aspects of R46. This resulting OIML Guide, G XX “ELECTRIC VEHICLE SUPPLY EQUIPMENT”, while based on R 46, is not a metering document in the sense of MID:ANNEX V ACTIVE ELECTRICAL ENERGY METERS (MI-003). The intention of this international Guide is to provide a blueprint of requirements and procedures for type testing, to be used by national regulators and approval authorities to set up their own legislation. In this Guide, the EVSE is considered as a unique built for purpose system which incorporates AC or DC energy metrology. Whether the metrology in the EVSE is accomplished using a separately type approved meter or integrated into the electronics of the EVSE does not affect the requirements for testing or performance of the EVSE.

Practical technical experience in testing and approving DC charging is lacking in some respects. Still, DC charging applications constitute an important, growing portion of the EV charging market, and fair trade of electrical energy in DC is deemed at least as important as in AC. Measuring DC energy by EVSE is therefore explicitly covered in this Guide, be it in a rudimentary way.

Immediately following the development of this Guide, the same OIML project group will begin working to produce a full Recommendation on EVSE. The major parts of this Guide are already styled as ‘part 1’ and ‘part 2’ of an OIML Recommendation. The Recommendation will be a finetuned, more elaborate version of the text of this Guide, and will contain all mandatory parts. Once the Recommendation on EVSE is published, OIML intends to retract this Guide.

## Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

- International Recommendations (OIML R), which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;
- International Documents (OIML D), which are informative in nature and intended to improve the work of the metrological services.

OIML Draft Recommendations and Documents are developed by technical committees or subcommittees which are formed by the Member States. Certain international and regional institutions also participate on a consultation basis.

Cooperative agreements are established between OIML and certain institutions, such as ISO and IEC, with the objective of avoiding contradictory requirements; consequently, manufacturers and users of measuring instruments, test laboratories, etc. may apply simultaneously OIML publications and those of other institutions.

International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

This publication - reference OIML G xx, edition xxxx (E) – was developed by the Working Group on the Revision of R 46 of the OIML Technical Committee TC 12/WG 3 . It was approved for final publication by the International Committee of Legal Metrology in xxxx.

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# Part 1 Metrological and technical requirements

## 1 Scope

This document provides guidance as to the metrological and technical requirements applicable to electric vehicle supply equipment (EVSE) subject to legal metrological controls. The requirements are provided for type approval, verification, re-verification and *in situ* testing. They also apply to modifications that may be made to existing approved devices.

The provisions set out here apply only to active electrical energy measurements and computation of transaction billing.

This Guide is structured very similarly to a Recommendation since it is the intention of the working group to transform it into a Recommendation as soon as possible.

## 2 Terms and Definitions

The terminology used in this Guide conforms to the OIML International Document D 11 “General Requirements for Electronic Measuring Instruments” [1], and conforms to the International Vocabulary of Basic and General Terms in Metrology (VIM) [3] and the International Vocabulary of Legal Metrology (VIML) [4]. Terminology from OIML International Document D 31, “General requirements for software controlled measuring instruments” [2] is also applicable particularly for 3.7 and the associated validation procedures in 4.3 In addition, for the purposes of this Guide, the following definitions shall apply:

### 2.1 Electric Vehicle Supply Equipment (EVSE)

A device intended to supply or receive electrical energy to or from an electric vehicle and to measure that energy, store and report the result to the customer, and if necessary, transmit the information to a billing system.

#### 2.1.1 EVSE with separately type approved meter

In this configuration the basic metrology is provided by a separately type approved meter which has been tested for compliance with R46 requirements.

#### 2.1.2 EVSE with embedded metrology

In this configuration the metrology is an integral part of the EVSE and not required to be separately type approved.

### 2.2 Definitions

#### 2.2.1 Connection point

Point where one electric vehicle is connected to the fixed installation. [definition 3.1.5 of IEC 61851-1]

Remark 1: In case the output cable is a fixed part of the charging system, this point is defined as the connector at the end of the cable. Otherwise, the connection point is defined as the point of the charging system where the cable is plugged in.

#### 2.2.2 Control system

A collection of hardware and software, which may include a load control switch as well as a communication interface, which collectively manage the process of charging.

#### 2.2.3 Client interface

A facility of the EVSE that may be local or remote that provides access to legally relevant transaction data to a user.

Note: National Authorities may require a local client interface (indicating device).

#### 2.2.4 Measuring element

Part of the EVSE that transforms a current and a voltage into a signal proportional to the power and or energy.

Note: A measuring element can be based on an electromagnetic, electrical or an electronic principle.



### **2.2.5 Current circuit**

Connections of the EVSE and part of the measuring element through which flows the current of the electric vehicle to which the EVSE is connected.

### **2.2.6 Voltage circuit**

Connections, components, wiring and cables of the EVSE which provide voltage to the electric vehicle.

### **2.2.7 Indicating device or display**

Part of the EVSE that implements the client interface either continuously or on demand.

Note 1: An indicating device may also be used to display other relevant information.

Note 2: An indicating device is local to the EVSE.

### **2.2.8 Energy register**

Part of the system that stores the energy measured in a transaction.

Note 1: In this document unless otherwise noted, register shall mean energy register.

Note 2: This energy register is not the same as the energy accumulation register in a R-46 compliant meter.

### **2.2.9 Adjustment device**

Device or function incorporated in the EVSE that allows the error curve to be shifted with a view to bringing errors (of indication) within the maximum permissible errors.

### **2.2.10 Ancillary device**

Device within the EVSE that is not used during the transaction.

Note: Since the testing used in this Guide is all transactional any device which is routinely required to be active during a transaction will have its effect tested automatically. Ancillary devices are devices which may or may not be active at any time but are not used as part of the transactional process.

Example: An EVSE might have a display which shows advertisements for a business. It would be an ancillary device.

### **2.2.11 Sub-assembly**

Part of a device having a recognizable function of its own.

### **2.2.12 Transaction**

The process of authorizing, connecting to the electric vehicle, delivering/receiving energy, terminating the delivery/receiving, presenting the information relevant to the process to the customer, transmitting and receiving acknowledgement of any billing information.

## **2.3 Metrological characteristics**

### **2.3.1 Current ( $I$ )**

RMS value of the electrical current flowing to or from the EVSE through the connection point.

### **2.3.2 Starting current ( $I_{st}$ )**

Lowest value of current specified at which the EVSE should register electrical energy at unity power factor and, for poly-phase EVSE, with balanced load.

### **2.3.3 Minimum current ( $I_{min}$ )**

Lowest value of current at which the EVSE is specified to meet the accuracy requirements of this Guide.

### **2.3.4 Transitional current ( $I_{tr}$ )**

Value of current at and above which the EVSE is specified to lie within the smallest maximum permissible error corresponding to the accuracy class of the EVSE.

### 2.3.5 Maximum current ( $I_{\max}$ )

Highest value of current at which the EVSE is specified by the manufacturer to meet the accuracy requirements of this Guide.

### 2.3.6 Voltage ( $U$ )

RMS value of the electrical voltage supplied to the electric vehicle at the connection point.

### 2.3.7 Nominal voltage ( $U_{\text{nom}}$ )

Voltage specified by the manufacturer for normal operation of the EVSE. An EVSE may have multiple  $U_{\text{nom}}$ .

### 2.3.8 Nominal frequency ( $f_{\text{nom}}$ )

Frequency of the voltage (and current) specified by the manufacturer for operation of the EVSE.

### 2.3.9 Harmonic

Part of a signal that has a frequency that is an integer multiple of the fundamental frequency of the signal. The fundamental frequency is generally the nominal frequency ( $f_{\text{nom}}$ ).

### 2.3.10 Harmonic number

Integer number used to identify a harmonic. It is the ratio of the frequency of a harmonic to the fundamental frequency of the signal.

### 2.3.11 Distortion factor ( $d$ )

Ratio of the RMS value of the harmonic content (obtained e.g. by subtracting from a non-sinusoidal alternating quantity its fundamental term) to the RMS value of the fundamental term. The distortion factor is usually expressed in percentage. It is equivalent to THD, total harmonic distortion.

### 2.3.12 Power factor (PF)

Ratio of the active power to the apparent power.

Note: An EVSE is not required to measure apparent energy or power factor. Performance is verified using a reference that can measure apparent energy and power factor.

### 2.3.13 Power, instantaneous

Rate at which energy is transported. Instantaneous power is the product of voltage and current at each instance of time.

$$p(t) = u(t) \cdot i(t)$$

where:

$u(t)$  is the instantaneous voltage

$i(t)$  is the instantaneous current

$p(t)$  is the instantaneous power

### 2.3.14 Power, active

The integral of the instantaneous power over a single cycle.

$$P = \frac{1}{T} \int_0^T u(t)i(t)dt$$

where:

$T$  is the period of the voltage waveform.

At sinusoidal conditions active power is the product of the RMS value of current and voltage and the cosine of the phase angle between them, calculated for each phase. It is usually expressed in kW.

Active power  $P = UI \cos \varphi$ .

### 2.3.15 Energy, active ( $E_a$ )

Instantaneous active power integrated over time.

$$E_a = \int_{\tau}^{\tau+kT} p(t) \cdot dt$$

where:

$E_a$  is the active energy.

$k$  is the number of cycles

Other symbols are as defined in 2.3.13

Note: (1) Active energy is usually expressed in kWh or MWh. Refer to 3.1 for requirements on units of measurement.

### 2.3.16 Relative error (of indication)

Measured quantity value minus reference quantity value, divided by the reference quantity value. The relative error is usually expressed as a percentage.

Note: Since this Recommendation deals only with relative error, the short form “error” is used for relative error.

### 2.3.17 Maximum permissible error (MPE)

Extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system. OIML D31::2019 3.1.28

Note 1: Usually, the term “maximum permissible errors” or “limits of error” is used where there are two extreme values.

Note 2: The term “tolerance” should not be used to designate ‘maximum permissible error’

Note: In this Recommendation, the maximum permissible error is a combination of the base maximum permissible error and the maximum permissible error shift as described in Annex B.

### 2.3.18 Base maximum permissible error (BMPE)

Extreme values of the error (of indication) of a EVSE, permitted by this Guide, when the current and power factor are varied within the intervals given by the rated operating conditions, and when the EVSE is otherwise operated at reference conditions.

Note: In this Guide, the maximum permissible error is a combination of the base maximum permissible error and the maximum permissible error shift as described in Annex B.

### 2.3.19 Maximum permissible error shift

Extreme values of the change in error (of indication) of an EVSE, permitted by this Guide, when a single influence factor is taken from its value at reference conditions and varied within the rated operating conditions. For each influence factor there is one corresponding maximum permissible error shift.

Note: In this Guide, the maximum permissible error is a combination of the base maximum permissible error and the maximum permissible error shift as described in Annex B.

### 2.3.20 Intrinsic error

Error of a measuring instrument, determined under reference conditions. [OIML D11:2013, 3.8]

### 2.3.21 Initial intrinsic error

Intrinsic error of a measuring instrument as determined prior to performance tests and durability evaluations. [OIML D11:2013, 3.9]

### 2.3.22 Minimum measured quantity (MMQ)

The minimum quantity of energy delivered in a transaction for which the manufacturer specifies that the EVSE will meet the BMPE of the EVSE’s accuracy class. The MMQ shall not be greater than 0.5 kWh.

### **2.3.23 Influence quantity**

Quantity that, in a direct measurement, does not affect the quantity that is actually measured, but affects the relation between the indication and the measurement result. [OIML D11:2013, 3.15]

Guide Comment: The definition of influence quantity is understood to include values associated with measurement standards, reference materials and reference data upon which the result of a measurement may depend, as well as phenomena such as short-term measuring instrument fluctuations and quantities such as ambient temperature, barometric pressure and humidity.

### **2.3.24 Influence factor**

Influence quantity having a value within the rated operating conditions of the measuring instrument specified in this Guide. [OIML D11:2013, 3.15.1]

### **2.3.25 Disturbance**

Influence quantity having a value within the limits specified in this Guide, but outside the specified rated operating conditions of the measuring instrument. [OIML D11:2013, 3.15.2]

Note: An influence quantity is a disturbance if the rated operating conditions for that influence quantity are not specified.

### **2.3.26 Rated operating condition**

Operating condition that must be fulfilled during measurement in order that a measuring instrument or measuring system perform as designed. [OIML D11:2013, 3.16]

Note: Rated operating conditions generally specify intervals of values for a quantity being measured and for any influence quantity.

### **2.3.27 Reference condition**

Operating condition prescribed for evaluating the performance of a measuring instrument or measuring system or for comparison of measurement results. [OIML D11:2013, 3.17]

Note 1 Reference operating conditions specify intervals of values of the measurand and of the influence quantities.

Note 2 In IEC 60050-300, item 311-06-02, the term “reference condition” refers to an operating condition under which the specified instrumental measurement uncertainty is the smallest possible.

### **2.3.28 Accuracy class**

Class of measuring instruments or measuring systems that meet stated metrological requirements that are intended to keep measurement errors or instrumental uncertainties within specified limits under specified operating conditions.

Note: In this Guide, the stated metrological requirements for accuracy class include permissible responses to disturbances.

### **2.3.29 Durability**

Ability of a measuring instrument to maintain its performance characteristics over a period of use. [OIML D11:2013, 3.18]

### **2.3.30 Significant fault**

A failure of the device when subjected to a disturbance in which the device appears to function correctly but is actually providing legally relevant data outside the acceptable limits. Ceasing to function is not a significant fault. If a disturbance interrupts a transaction, then either: (a) the transaction must be cancelled or (b) when the disturbance is removed, the transaction must be completed correctly.

### **2.3.31 Checking facility**

Facility that is incorporated in the EVSE and which enables faults that would otherwise be significant faults to be detected and acted upon in such a way that incorrect registration is prohibited. [OIML D11:2013, 3.19 modified]

Faults that are detected and acted upon by means of a checking facility shall not be considered as significant faults.

### **2.3.32 Bidirectional (energy) flow**

Capability of EVSE to measure energy flow in both directions (to EV and from EV).

**2.3.33 Positive direction only (energy) flow**

Capability of EVSE to measure energy flow in only one direction (to EV).

**2.3.34 Positive (energy) flow**

Direction of energy flow to the EV.

**2.3.35 Negative (energy) flow**

For bidirectional and unidirectional EVSE, direction of energy flow from the EV through the EVSE to the nominal supply. Note, for positive direction only, the opposite direction is termed reverse energy flow (see definition).

**2.3.36 Reverse (energy) flow**

For positive direction only EVSE, direction of flow in the opposite direction to positive.

**2.3.37 Legally relevant**

Software/hardware/data or part of the software/hardware/data of a measuring instrument which interferes with properties regulated by legal metrology, e.g. the accuracy of the measurement or the correct functioning of the measuring instrument.

**2.3.38 Legally relevant transaction data**

At a minimum the legally relevant transaction data shall include energy transferred, unit price and total value of the transaction.

**3 Metrological Requirements****3.1 Units of measurement**

The active electrical energy shall be expressed using one of the following symbols: Wh, kWh, MWh, GWh.

**3.2 Rated operating conditions**

Rated operating conditions are specified in Table 1.

**Table 1 Rated operating conditions**

Condition or influence quantity	Values, Ranges																									
Frequency	(1-Δ )f <sub>nom</sub> ≤ f ≤(1+Δ) f <sub>nom</sub> where f <sub>nom</sub> is to be specified by the manufacturer. If the manufacturer specifies more than one nominal frequency, the rated operating conditions shall be the combination of all (1-Δ )f <sub>nom</sub> ≤ f ≤(1+Δ) f <sub>nom</sub> intervals National authorities shall specify a value for Δ which is appropriate for the stability of their distribution network. Values typically range from 0.1% to 2%.																									
Voltage	0.9 times lowest U <sub>nom</sub> to 1.1 times highest U <sub>nom</sub>																									
Current	I <sub>max</sub> is to be specified by the manufacturer. <table><tr><td>Mode</td><td>AC</td><td>AC</td><td>DC</td><td>DC</td></tr><tr><td>I<sub>st</sub></td><td>1.5A</td><td>0.02 I<sub>max</sub></td><td>5</td><td>5</td></tr><tr><td>I<sub>min</sub></td><td>3.0A</td><td>0.05 I<sub>max</sub></td><td>10</td><td>10</td></tr><tr><td>I<sub>tr</sub></td><td>5.0A</td><td>0.10 I<sub>max</sub></td><td>20</td><td>40</td></tr><tr><td>I<sub>max</sub></td><td>≤ 80A</td><td>&gt;80A</td><td>≤200</td><td>&gt;200</td></tr></table>	Mode	AC	AC	DC	DC	I <sub>st</sub>	1.5A	0.02 I <sub>max</sub>	5	5	I <sub>min</sub>	3.0A	0.05 I <sub>max</sub>	10	10	I <sub>tr</sub>	5.0A	0.10 I <sub>max</sub>	20	40	I <sub>max</sub>	≤ 80A	>80A	≤200	>200
Mode	AC	AC	DC	DC																						
I <sub>st</sub>	1.5A	0.02 I <sub>max</sub>	5	5																						
I <sub>min</sub>	3.0A	0.05 I <sub>max</sub>	10	10																						
I <sub>tr</sub>	5.0A	0.10 I <sub>max</sub>	20	40																						
I <sub>max</sub>	≤ 80A	>80A	≤200	>200																						
Power factor	≥0.98																									
Temperature	From lower temperature limit to upper temperature limit as specified by manufacturer. The manufacturer shall specify the lower temperature limit from the values: -55 °C, -40 °C, -25 °C, -10 °C, +5 °C. The manufacturer shall specify the upper temperature limit from the values: +30 °C, +40 °C, +55 °C, +70 °C, +85 °C.																									

Humidity and water	With respect to humidity, the manufacturer shall specify the environment class for which the system is intended:  H1: enclosed locations where the instruments are not subjected to condensed water, precipitation, or ice formations;  H2: enclosed locations where the instruments may be subjected to condensed water, to water from sources other than rain and to ice formations;  H3: open locations with average climatic conditions.
Harmonics	The voltage and current shall be allowed to deviate from the sinusoidal form, as given by the requirements in clause 3.3.5, Table 4, “Harmonics in voltage and current circuits”.
Load balance	All loads shall be balanced.

### 3.3 Accuracy requirements

#### 3.3.1 General

The manufacturer shall specify the accuracy class of the EVSE to be one of A, B or C.

The EVSE shall be designed and manufactured such that its error does not exceed the maximum permissible error for the specified class under rated operating conditions.

The EVSE shall be designed and manufactured such that, when exposed to disturbances, significant faults do not occur.

#### 3.3.2 Direction of energy flow

Where a manufacturer has specified that an EVSE is capable of bidirectional energy flow, the EVSE shall correctly handle both positive and negative mean energy flow and shall fulfil the requirement of this Guide for energy flow in both directions. The polarity of energy flow shall be defined by the manufacturer’s connection instructions for the EVSE. For AC EVSE the mean energy flow refers to the active power integrated over at least one cycle of the nominal frequency.

An EVSE shall fall into at least one of the following categories:

- Two-register, bidirectional; where the EVSE is specified as capable of measuring both positive and negative mean energy flow, as defined by the connection of the EVSE and electric vehicle, and where the positive result and negative result are placed in different registers.
- Single-register, positive direction only; where the EVSE is specified as capable of measuring and registering only positive mean energy flow. It may inherently, by its design, register only positive mean energy flow or it may be equipped with a reverse running detent. The manufacturer shall specify which method is used.
- For bidirectional EVSE, energy registration shall occur in the correct register when the direction of flow changes.

Note: The terms “single-register” and “two-register” in the list above refer to the basic energy register(s) only. A EVSE may have other registers, e.g. for storage of tariff and/or phase information.

Note: The national authority may determine what EVSE types and calculation methods are appropriate.

#### 3.3.3 Base maximum permissible errors

The intrinsic error shall be within the base maximum permissible error stated in Table 2 when the current is varied within the limits given by Table 2 (operating range), and when the EVSE is otherwise operated at reference conditions and the minimum measured quantities.

**Table 2. Base maximum permissible errors**

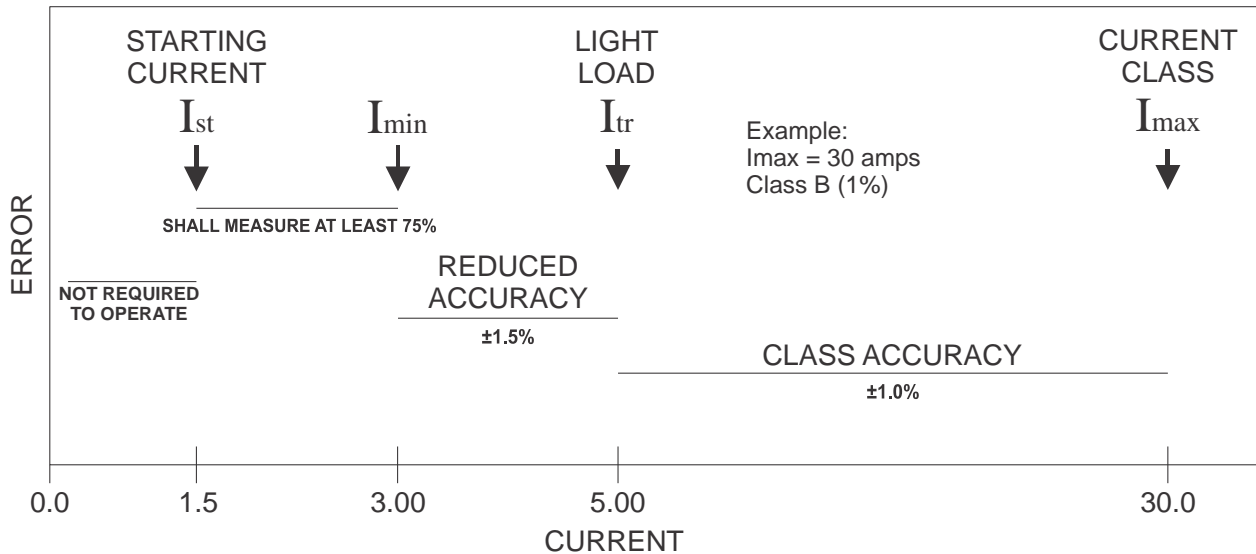
Quantity		Base maximum permissible errors (%) for of class		
Current $I$	Power Factor	A	B	C
$I_{\min} \leq I < I_{tr}$	Unity	$\pm 2.5$	$\pm 1.5$	$\pm 1.0$

$I_{tr} \leq I \leq I_{max}$	Unity	$\pm 2.0$	$\pm 1.0$	$\pm 0.5$
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Note: The combined maximum permissible error (CMPE) and the combined maximum error (CME) resulting from the type evaluation can be calculated as presented in Annex B. Regional or national authorities may require this CME to fulfil the CMPE or to meet other limits (not related to the CMPE) determined by the regional or national authorities.

Note: Figure 1 is provided as an example of the use of the various break points for accuracy with respect to current. The figure represents an accuracy class B EVSE with  $I_{max} = 30$  A.

**Figure 1 BMPE versus current requirements**



### 3.3.4 No load

No significant energy shall be registered under conditions of no load.

Note: the EVSE may stop measuring energy for currents below  $I_{st}$ .

### 3.3.5 Allowed effects of influence quantities

The temperature coefficient of the EVSE shall fulfil the requirements of Table 3 when the EVSE is otherwise operated at reference conditions.

**Table 3. Limits for temperature coefficient of error**

Influence quantity	Limits for temperature coefficient (%/K) for EVSE of class <sup>(1)</sup>		
	A	B	C
Temperature coefficient, over any interval of the temperature range, which is not less than 15 K and not greater than 23 K, for current $I_{tr} \leq I \leq I_{max}$	$\pm 0.1$	$\pm 0.05$	$\pm 0.03$
(1) These values are doubled below -10 °C and above +50 °C.			

When the load current is held constant at a point within the rated operating range with the EVSE otherwise operated at reference conditions, and when any single influence quantity is varied from its value at reference conditions to its extreme values defined in Table 4, the variation of error shall be such that the additional percentage error is within the corresponding limit of error shift stated in Table 4. The EVSE shall continue to function after the completion of each of these tests.

**Table 4 Limit of error shift due to influence quantities.**

Influence quantity	Value	Limit of error shift (%) for EVSE of class				
		Test	Current	A	B	C
Self-heating	Continuous current at $I_{\max}$	6.2.2	$I_{\max}$	$\pm 1$	$\pm 0.5$	$\pm 0.25$
Voltage variation	0.9 times lowest $U_{\text{nom}}$ to 1.1 times highest $U_{\text{nom}}$	6.3.3 ††	$I_{\text{tr}} \leq I \leq I_{\max}$	$\pm 1.0$	$\pm 0.7$	$\pm 0.2$
Frequency variation	$f_{\text{nom}} \pm \Delta\%$	6.3.4 ††	$I_{\text{tr}} \leq I \leq I_{\max}$	$\pm 0.8$	$\pm 0.5$	$\pm 0.2$
Harmonics in voltage and current circuits <sup>(1)</sup> (AC EVSE ONLY)	$d < 5\% I$ $d < 10\% U$	6.3.5 ††	$I_{\text{tr}} \leq I \leq I_{\max}$	$\pm 1.0$	$\pm 0.6$	$\pm 0.3$
Ripple on voltage and current circuits (DC EVSE ONLY)	$d < ??\% I$ $d < ??\% U$					
Reversed phase sequence (3-phase only)	Any two phases Interchanged	6.3.6 ††	$I_{\text{tr}} \leq I \leq I_{\max}$	$\pm 1.5$	$\pm 1.5$	$\pm 0.1$
Continuous (DC) magnetic induction of external origin <sup>(2)</sup>	200 mT at 30 mm from core surface <sup>(2)</sup>	6.3.7	$I_{\text{tr}} \leq I \leq I_{\max}$	$\pm 3$	$\pm 1.5$	$\pm 0.75$
Magnetic field (AC, power of frequency) of external origin.	400 A/m	6.3.8	$I_{\text{tr}} \leq I \leq I_{\max}$	$\pm 2.5$	$\pm 1.3$	$\pm 0.5$
Radiated, RF, electromagnetic fields	$f = 80$ to $6000$ MHz, Field strength $\leq 30$ V/m	6.3.9.1 ††	$I_{\text{tr}} \leq I \leq I_{\max}$	$\pm 3$	$\pm 2$	$\pm 1$
Conducted disturbances, low frequency	2 kHz – 150 kHz	6.3.9.2 ††	$I_{\text{tr}} \leq I \leq I_{\max}$			
Conducted disturbances, induced by radio frequency fields <sup>(3)</sup>	$f = 0.15$ to $80$ MHz, Amplitude $\leq 10$ V	6.3.9.3 ††	$I_{\text{tr}} \leq I \leq I_{\max}$	$\pm 3$	$\pm 2$	$\pm 1$
Operation of ancillary devices	Ancillary devices operated with $I = I_{\min}$ and $I_{\max}$	6.3.10	$I_{\text{tr}} \leq I \leq I_{\max}$	1/3 BMPE	1/3 BMPE	1/3 BMPE



† These tests are not required when the metrology is implemented by a separately approved meter whose type approval specifications meet or exceed those of this guide.

‡ These tests are not required for DC systems where the EVSE consists of multiple enclosures connected by DC power busses.

(1) As long as the RMS value of the current is not higher than  $I_{\max}$  and the peak value of the current is not higher than  $1.41 \cdot I_{\max}$ .

(2) Manufacturers may additionally include an alarm upon detection of a continuous (DC) magnetic induction of greater than 200 mT. National authorities may select a lower magnetic induction for national requirements.

(3) Direct or indirect, conducted disturbances induced by radio-frequency fields.

### 3.3.6 Allowed effects of disturbances

#### 3.3.6.1 General

The EVSE shall withstand disturbances that may be encountered under conditions of normal use; as stated in clause 3.3.1, no significant fault shall occur for any of the disturbances listed in Table 5, Table 6 and Table 7.

If an EVSE is operated under the conditions outlined in Table 5, Table 6 or Table 7 and no transaction is in progress, a change in the registers or pulses of the test output shall not be considered as a significant fault.

#### 3.3.6.2 Electrical Disturbances

The electrical disturbances tests can be performed either individually with an error check after each test or as a group with a single error check after all tests have been performed. An error shift larger than 1.0 BMPE shall not occur.

**Table 5. Electrical Disturbances**

Disturbance quantity	Ref.	Level of disturbance	Allowed effects
Electrostatic discharges	6.4.2	8 kV contact discharge; 15 kV air discharge.	No significant fault.
Fast transients	6.4.3 ‡	Voltage and current circuits: 2kV; Auxiliary circuits: 1.0 kV.	No significant fault.
Voltage dips	6.4.4	Test a: 30%, 0.5 cycles Test b: 60%, 1 cycle Test c: 60%, 25/30 cycles (1)	No significant fault. EVSE may shutdown.
Voltage interruptions	6.4.4	0%, 250/300 cycles (3)	No significant fault.
Surges on AC mains power lines	6.4.5 †‡	Voltage circuits: 1kV line to line, 2kV line to earth; Auxiliary circuits: 1kV line to line, 2kV line to earth.	No significant fault.
Short-time overcurrent	6.4.6 †‡	$5 \cdot I_{\max}$ .	No significant fault. No damage shall occur.
Impulse voltage	6.4.7	1.5 kV $U$ ( $100 \leq U < 150$ ) 2.5 kV $U$ ( $150 \leq U < 300$ )	No significant fault. No damage shall occur.

† These tests are not required when the metrology is implemented by a separately approved meter whose type approval specifications meet or exceed those of this guide.

‡ These tests are not required for DC systems where the EVSE consists of multiple enclosures connected by DC power busses.

### 3.3.6.3 Environmental Disturbances

The environmental disturbances tests can be performed either individually with an error check after each test or as a group with a single error check after all tests have been performed. An error shift larger than 1.0 BMPE shall not occur.

**Table 6. Environmental Disturbances**

Disturbance quantity	Ref.	Level of disturbance	Allowed effects
Protection against solar radiation	6.4.8.1	0.76 W·m <sup>2</sup> ·nm <sup>-1</sup> at 340 nm, with cycling rig for 66 days.	No alteration in appearance or impairment in functionality, metrological properties and sealing.
Protection against ingress of dust	6.4.8.2	IP 54, category 2 enclosure	No interference with correct operation or impairment of safety, including tracking along creepage distances.
Dry heat	6.4.8.3	One standard temperature higher than upper specified temperature limit, 2 h	No significant fault.
Cold	6.4.8.4	One standard temperature lower than lower specified temperature limit, 2 h	No significant fault.
Damp Heat	6.4.8.5, 6.4.8.6	H1: 30 °C, 85%; H2: Cyclic 25 °C, 95% to 40 °C, 93%; H3: Cyclic 25 °C, 95% to 55 °C, 93%.	No significant fault. No evidence of any mechanical damage or corrosion.
Water	6.4.8.7	H3 only, 0.07 L/min (per nozzle), 0 ° and 180 °, 10 min	No significant fault. No evidence of any mechanical damage or corrosion.
Durability	6.4.9	High current and/or temperature for a sustained period of time.	No significant fault.
† These tests are not required when the metrology is implemented by a separately approved meter whose type approval specifications meet or exceed those of this guide.			
‡ These tests are not required for DC systems where the EVSE consists of multiple enclosures connected by DC power busses.			

### 3.3.7 Mechanical disturbances

Mechanic disturbances are intended to simulate conditions encountered during transportation. National authorities may eliminate any of these requirements when the EVSE is too large to perform the associated test reasonably and at a reasonable cost. These requirements may also be eliminated from type approval if *in situ* testing is performed prior to an EVSE being put into service.

**Table 7. Mechanical Disturbances**

<b>Disturbance quantity</b>	<b>Ref.</b>	<b>Level of disturbance</b>	<b>Allowed effects</b>
Vibration	6.4.10.1†‡	Vibration in three mutually perpendicular axes.	No significant fault. Function of the EVSE shall not be impaired.
Shock	6.4.10.2†‡	Pulse shape: Half-sine, Peak acceleration: 30 g <sub>n</sub> , Pulse duration: 18 ms.	No significant fault. Function of the EVSE shall not be impaired.
† These tests are not required when the metrology is implemented by a separately approved meter whose type approval specifications meet or exceed those of this guide.			
‡ These tests are not required for DC systems where the EVSE consists of multiple enclosures connected by DC power busses.			

### 3.4 Markings

National authorities shall determine what information must be marked on every EVSE. The EVSE shall have a clearly visible nameplate and the following are recommended minimum markings:

- approval mark
- approval number/identifier
- manufacturer
- year of manufacture
- manufacturer model
- serial number
- voltage range
- current range (minimum current and maximum current)
- frequency
- temperature range
- accuracy class
- MMQ (minimum measurement quantity)

The markings shall be indelible, distinct and legible from outside the EVSE. The markings of EVSE's intended for outdoor locations shall withstand solar radiation.

If the serial number is affixed to dismountable parts, the serial number shall also be provided in a position where it is not readily disassociated from parts determining the metrological characteristics.

Symbols or their equivalent may be used where appropriate. See e.g. IEC 62053-52, Electricity metering equipment (AC) - Particular requirements - Part 52: Symbols, or other designations accepted by local jurisdictions.

### 3.5 Suitability for use

#### 3.5.1 General

3.5.1.1 EVSEs shall fulfil all requirements in this Guide. This includes all metrological requirements and the requirements on software and the internal clock (if applicable).

Remark 1: Additionally, national authorities may specify requirements to measure the total energy consumption from the grid, delivered by the energy supplier.

Remark 2: National authorities may require additional legally relevant information to be made accessible to the end user, such as time and date, customer ID, station ID, meter ID.

3.5.1.2 Accuracy shall be determined at the connection point. If the EVSE has integral external connecting cables and if corrections are applied to compensate for the energy loss introduced by such cables, those cables shall be sealed.

3.5.1.3 The EVSE shall have no means to allow measured energy to be diverted between point of measurement and the EV.

3.5.1.4 If an EVSE is capable of receiving electrical energy from the vehicle to be transferred to the source, then:

- a) the client interface shall be able to display all necessary information related to the transactions in both directions,
- b) the EVSE shall be of the "two-register, bidirectional" category, as defined in section 3.3.2 of this Guide,
- c) the accuracy requirements are fulfilled for both directions, and
- d) all other requirements are applicable to this kind of transaction as well.

### 3.5.2 Transactions

3.5.2.1 When settlement takes place at a later moment in time than the completion of the transaction, the legally relevant data referenced in 3.6.1.1 must be either stored in the EVSE or secured and stored externally for retrieval at the later time.

Note: National authorities may require that the legally relevant data is stored inside the EVSE. For externally stored data, national authorities may also impose specific requirements on data security.

3.5.2.2 Means shall be provided to automatically terminate the transaction in the event of an unauthorized break in the connection with the vehicle. Any legally relevant data associated with the terminated transaction shall remain valid until the transaction is completed.

### 3.5.3 Multiple Tariffs

EVSE that can apply multiple tariffs during delivery shall meet the following requirements:

- 1) they must be able to measure and store data relevant for billing,
- 2) the minimum storage period for this data can be determined by national authorities,
- 3) the sum of all energy registered in multi-tariff registers shall be equal to the total energy transferred during the transaction,
- 4) only one register can be active at any period of time during a transaction,
- 5) it shall be clear for each part of the transaction:
  - a. the amount of energy transferred,
  - b. the time interval over which the energy was transferred,
  - c. the direction of energy transfer, if applicable,
  - d. the unit price that was applied.

### 3.5.4 Power Outage

In the event of a supply power outage:

- 1) the transaction shall be paused at the time of the supply power outage,
- 2) once power is restored,
  - a) if the EVSE is able to determine it is connected to the same vehicle before and after the supply power outage, the EVSE may continue charging without additional authorization and the transaction that was in process can complete normally,
  - b) if the EVSE is NOT able to determine it is connected to the same vehicle before and after the supply power outage, the EVSE shall terminate the transaction at the point that the power failed,
    - i) the EVSE may abandon the charging session with no charge to the customer, or
    - ii) the EVSE may complete the transaction charging the customer for only the services provided up to the point of power failure. In this case all requirements for a completed transaction apply.

### **3.6 Access to data**

#### **3.6.1 Readability of result**

3.6.1.1 An EVSE shall make the legally relevant data accessible to the end user through the client interface. This shall be done in accordance with 3.6.1.1.1 and/or 3.6.1.1.2.

3.6.1.1.1 The EVSE is provided with an indicating device locally visible from the outside of the EVSE under normal conditions of use and is capable of showing the legally relevant data as indicated in 3.6.4.1.

3.6.1.1.2 The EVSE is provided with a non-local client interface to provide the end user access to the data, where the following minimum requirements must be fulfilled:

- the EVSE is provided with communication means to send out all necessary legally relevant data as indicated in 3.6.4.1,
- all transported legally relevant data is secured by the EVSE, by state-of-the-art cryptographic means,
- the legally relevant data shall be made accessible to the end user together with all information required to check the authenticity, using fit for purpose technical means, which are not part of the EVSE.

Remark 3: National authorities may decide whether a local physical client interface according to clause 3.6.1.1.1 is mandatory or whether the solution according to clause 3.6.1.1.2 can be allowed or whether additional requirements are needed.

Remark 4: State of the art cryptographic means are published by institutes like NIST, BSI etc.

#### **3.6.2 Client interfaces**

The following requirements apply to all client interfaces;

- they shall be able to display all data relevant for billing purposes,
- for multi-tariff devices, the data for each tariff applied shall be displayed.

##### **3.6.2.1 Local indicating devices**

EVSE having at least one local indicating device that implements the client interface shall meet the following requirements:

- it shall be easy to read,
- any decimal fractions shall be clearly indicated,
- It shall not be significantly affected by exposure to normal operating conditions over the maximum duration of the EVSE lifetime.

Note: The National authority may or may not require a local indicating display.

#### **3.6.3 Registers**

Electronic registers shall be non-volatile so that they retain stored values upon loss of power. Stored values shall not be overwritten and shall be capable of being retrieved upon restoration of power. The register shall be capable of storing and displaying an amount of energy of at least 999kWh. This capability for storage and display applies to all registers relevant for billing including positive and negative flow registers for bidirectional EVSE and tariff registers for multi-tariff EVSE.

Note: The National Authority may change the energy required for register rollover.

In the case of electronic registers, the minimum retention time is until the transaction is finalized or cancelled. If electronic indicating devices have segments, then the EVSE shall be provided with a display test that switches all the display segments on then off for the purpose of determining whether all display segments are working.

The system shall have one or more registers for the energy delivered to the electrical vehicle for a transaction, which shall be reset to zero at the beginning of a new transaction. The reset to zero function shall be disabled while a charging event is ongoing.

### 3.6.4 Testability

3.6.4.1 The EVSE shall provide legally relevant energy data, processed with a resolution of 0.0001 kWh or better where the least significant digit increments by 1.

3.6.4.2 The EVSE shall provide price per kWh and total value of transaction data.

3.6.4.3 The primary mode of testing shall be based on the energy displayed on the client interface of the EVSE. Transaction data should be read directly from the client interface or from the cryptographic secured data-package of the legally relevant data, via a communication interface.

If present, testing may also be performed while using a dedicated pulse output. The pulse output shall conform to the following:

3.6.4.3.1 The energy per pulse shall be no greater than the resolution of the client interface.

3.6.4.3.2 There is a clear relationship between the pulse output and the indication on the client interface. Specifically, the energy represented by the pulse train during a transaction shall agree with that displayed on the client interface within  $\pm 1$  least significant digit.

3.6.4.3.3 The characteristics of the optical output should conform to the following:

The wavelength of the radiated signals for emitting systems shall be between 800 nm and 1 000 nm.

The optical output in the EVSE shall generate a signal with a radiation strength  $E_T$  over a reference surface (optically active area) at a distance of 10 mm  $\pm$  1 mm from the surface of the EVSE, with the following limiting values:

ON-condition :  $250 \mu\text{W}/\text{cm}^2 \leq E_T \leq 7\,500 \mu\text{W}/\text{cm}^2$

OFF-condition:  $E_T \leq 10 \mu\text{W}/\text{cm}^2$

The existence of a pulse output does not eliminate the requirements of 3.6.4.1 and 3.6.4.2.

## 3.7 Protection of metrological properties

### 3.7.1 General

EVSE shall be provided with the means to protect their metrological properties. National authorities shall determine levels of authorised access for software protection (3.7.3), parameter protection (3.7.4) and checking facility event record (3.7.8).

All means to protect the metrological properties of an EVSE intended for outdoor locations shall withstand solar radiation.

### 3.7.2 Software requirements

Legally relevant software of an EVSE shall be clearly identified with the software version or another token. The identification may consist of more than one part but at least one part shall be dedicated to the legal purpose. The identification shall be inextricably linked to the software itself and shall be presented on command or displayed during operation. It is permissible to have more than one legally relevant software part, however each legally relevant software part shall be identified.

As an exception, an imprint of the software identification on the EVSE shall be an acceptable solution if it satisfies the following conditions:

- a) The user interface does not have any control capability to activate the indication of the software identification on the display, or the display does not technically allow the identification of the software to be shown
- b) After production of the EVSE a change of the software is not possible, or only possible if the hardware or a hardware component is also changed.

Note: The manufacturer of the hardware or the concerned hardware component is responsible for ensuring that the software identification is conspicuously and correctly marked on the EVSE.

The software identification and the means of identification shall be stated in the type approval certificate.

### **3.7.3 Software protection**

#### **3.7.3.1 Prevention of misuse**

An EVSE shall be constructed in such a way that possibilities for unintentional, accidental, or intentional misuse are minimal.

#### **3.7.3.2 Fraud protection**

3.7.3.2.1 Legally relevant software shall be protected in such a way that evidence of any intervention (e.g. software updates, parameters changes) shall be apparent. Updates to legally relevant software or legally relevant software parameters are permitted if the EVSE complies with requirements under section 3.7.7; otherwise, legally relevant software shall be secured against unauthorised modification, loading, or changes by swapping the memory device. Mechanical sealing or other technical means may be necessary to secure EVSE. Audit trails are considered to be part of the legally relevant software and should be protected as such.

3.7.3.2.2 Only clearly documented functions (see 4.1) are allowed to be activated by the user interface, which shall be realized in such a way that it does not facilitate fraudulent use.

3.7.3.2.3 Software protection shall comprise of appropriate sealing by mechanical, electronic and/or cryptographic means, making an intervention impossible or evident.

Examples:

- a) The software of a measuring instrument is constructed such that there is no way to modify the parameters and legally relevant configuration but via a switch protected menu. This switch is mechanically sealed in the inactive position, making modification of the parameters and of the legally relevant configuration impossible. To modify the parameters and configuration, the switch has to be switched, inevitably breaking the seal by doing so.
- b) The software of a measuring instrument is constructed such that there is no way to access the parameters and legally relevant configuration but by authorized persons. The access is recorded in an audit trail including the identity of the person (or at least of the smart card used).

Note: As an example, if a person wants to enter the parameter menu item a smart card containing a PIN as part of a cryptographic certificate could be used. The software of the instrument must be able to verify the authenticity of the PIN by the certificate and allows the parameter menu item to be entered.

#### **3.7.4 Parameter protection**

Parameters that fix the legally relevant characteristics of the EVSE shall be secured against unauthorized modification. If necessary for the purpose of verification, the current parameter settings shall be capable of being displayed.

Device-specific parameters may be adjustable or selectable only in a special operational mode of the EVSE. They may be classified as those that should be protected (unalterable) and those that may be accessed (settable parameters) by an authorized person, e.g., the instrument owner, repairer.

National authorities may require an additional totalizing register, which cannot be reset without breaking a metrological seal (physical and/or digital seal). Zeroing the totalizing register that stores the total energy of all metered transactions shall be considered as a modification of a device specific parameter. Therefore, all relevant requirements applicable to device specific parameter are applicable to the zeroing operation.

It shall not be possible to make any modifications to software parameters during a transaction.

National regulations may prescribe that certain device-specific parameters to be available to the instrument owner. In such a case, the EVSE shall be fitted with a facility to automatically and non-erasably record any adjustment of the device-specific parameter, e.g., an audit trail. The instrument shall be capable of presenting the recorded data.

The traceability means and records are part of the legally relevant software and should be protected as such. The software employed for displaying the audit trail belongs to the fixed legally relevant software.

Note: An event counter is not a technically acceptable solution.

### 3.7.5 Separation of electronic devices and sub-assemblies

Legally relevant parts of an EVSE – whether software or hardware parts – shall not be inadmissibly influenced by other parts of the EVSE.

3.7.5.1 Sub-assemblies or electronic devices of an EVSE that perform legally relevant functions shall be identified, clearly defined, and documented. They form the legally relevant part of the measuring system. If the sub-assemblies that perform legally relevant functions are not identified, all sub-assemblies shall be considered to perform legally relevant functions.

Example:

- a) An EVSE is equipped with a WiFi interface for connecting an electronic device to read out measurement values. The EVSE stores all the relevant quantities and keeps the values available for being read out until the transaction is finalized. In this system only the EVSE is the legally relevant device. Other legally non-relevant devices may exist and may be connected to the interface of the instrument provided requirement 3.7.5.2 is fulfilled. Securing of the data transmission itself (see 3.7.9) is not required.

3.7.5.2 During type testing, it shall be demonstrated that the relevant functions and data of sub-assemblies and electronic devices cannot be inadmissibly influenced by commands received via the interface.

This implies that there is an unambiguous assignment of each command to all initiated functions or data changes in the sub-assembly or electronic device.

Note: If “legally relevant” sub-assemblies or electronic devices interact with other “legally relevant” sub-assemblies or electronic devices, refer to 3.7.9.

Examples:

- a) The software of the EVSE (see example of 3.7.5.1, above) is able to receive commands for selecting the quantities required. It combines the measurement value with additional information – e.g. time stamp, EVSE ID – and sends this data set back to the requesting device. The software only accepts commands for the selection of valid allowed quantities and discards any other command, sending back only an error message. There may be securing means for the contents of the data set but they are not required, as the transmitted data set is not subject to legal control.
- b) Inside the housing that can be sealed there is a switch that defines the operating mode of the EVSE: one switch setting indicates the verified mode and the other the non-verified mode (securing means other than a mechanical seal are possible; see examples 3.7.3.2.3). When interpreting received commands the software checks the position of the switch: in the non-verified mode the command set that the software accepts is extended compared to the mode described above; e.g. it may be possible to adjust the calibration factor by a command that is discarded in the verified mode.

### 3.7.6 Separation of software parts

3.7.6.1 All software modules (programs, subroutines, objects, etc.) that perform legally relevant functions or that contain legally relevant data domains form the legally relevant software part of an EVSE; it shall be made identifiable as described in 3.7.2. If the software modules that perform legally relevant functions are not identified, the whole software shall be considered as legally relevant.

3.7.6.2 If the legally relevant software part communicates with other software parts, a software interface shall be defined. All communication shall be performed exclusively via this interface. The legally relevant software part and the interface shall be clearly documented. All legally relevant functions and data domains of the software shall be described to enable a type approval authority to decide on correct software separation.

3.7.6.3 The software interface consists of program code and dedicated data domains. Defined coded commands or data are exchanged between the software parts by storing to the dedicated data domain by one software part and reading from it by the other. Writing and reading program code is part of the software interface.

3.7.6.4 There shall be an unambiguous assignment of each command to all initiated functions or data changes in the legally relevant part of the software. Commands that communicate through the software



interface shall be declared and documented. Only documented commands are allowed to be activated through the software interface. The manufacturer shall state the completeness of the documentation of commands.

### **3.7.7 Updates to Legally Relevant Software**

Updating the legally relevant software of an EVSE in the field should be considered as:

- a modification of the EVSEer, when exchanging the software with another approved version;
- a repair of the EVSE, when re-installing the same version.

An EVSE which has been modified or repaired while in service may require initial or subsequent verification, dependant on national regulations.

National authorities may prescribe that the software update mechanism is disabled by means of a sealable setting (physical switch, secured parameter) where software updates for instruments in use is not allowed. In this case it must not be possible to update legally relevant software without breaking the seal.

Software which is not necessary for the correct functioning of the EVSE does not require verification after being updated.

Only versions of legally relevant software that conform to the approved type are allowed for use

#### **3.7.7.1 Verified Update**

The software to be updated can be loaded locally, i.e. directly on the measuring device, or remotely via a network. Loading and installation may be two different steps or combined into one, depending on the needs of the technical solution. A person should be on the installation site of the EVSE to check the effectiveness of the update. After the update of the legally relevant software of an EVSE (exchange with another approved version or re-installation) the EVSE is not allowed to be employed for legal purposes before a verification of the instrument has been performed and the securing means have been renewed.

#### **3.7.7.2 Traced Update**

The software is implemented in the instrument according to the requirements for Traced Update (3.7.7.2.1 to 3.7.7.2.7). Traced Update is the procedure of changing software in a verified instrument or device after which the subsequent verification by a responsible person at place is not necessary. The software to be updated can be loaded locally, i.e. directly on the measuring device or remotely via a network. The software update is recorded in an audit trail. The procedure of a Traced Update comprises several steps: loading, integrity checking, checking of the origin (authentication), installation, logging and activation.

3.7.7.2.1 Traced Update of software shall be automatic. On completion of the update procedure the software protection environment shall be at the same level as required by the type approval.

3.7.7.2.2 The target EVSE shall have fixed legally relevant software that cannot be updated and that contains all of the checking functions necessary for fulfilling Traced Update requirements.

3.7.7.2.3 Technical means shall be employed to guarantee the authenticity of the loaded software, i.e. that it originates from the owner of the type approval certificate. If the loaded software fails the authenticity check, the instrument shall discard it and use the previous version of the software or switch to an inoperable mode.

3.7.7.2.4 Technical means shall be employed to ensure the integrity of the loaded software, i.e. that it has not been inadmissibly changed before loading. This can be accomplished by adding a checksum or hash code of the loaded software and verifying it during the loading procedure. If the loaded software fails this test, the instrument shall discard it and use the previous version of the software or switch to an inoperable mode. In this mode, the measuring functions shall be inhibited. It shall only be possible to resume the download procedure, without omitting any steps in the process for Traced Update.

3.7.7.2.5 Appropriate technical means, e.g. an audit trail, shall be employed to ensure that Traced Updates of legally relevant software are adequately traceable within the instrument for subsequent verification and surveillance or inspection.

The audit trail shall contain at minimum the following information: success/failure of the update procedure, software identification of the installed version, software identification of the previous installed version, time

stamp of the event, identification of the downloading party. An entry shall be generated for each update attempt regardless of the success.

The storage device that supports the Traced Update shall have sufficient capacity to ensure the traceability of Traced Updates of legally relevant software between at least two successive verifications in the field or inspection. After having reached the limit of the storage for the audit trail, it shall be ensured by technical means that further downloads are impossible without breaking a seal.

Note: This requirement enables inspection authorities, which are responsible for the metrological surveillance of legally controlled instruments, to back-trace Traced Updates of legally relevant software over an adequate period of time (depending on national legislation).

3.7.7.2.6 It is assumed that the manufacturer of the EVSE keeps his customer well informed about updates of the software, especially the legally relevant part, and that the customer will not deny updating it. Furthermore, it is assumed that manufacturer and customer, user, or owner of the instrument will agree on an appropriate procedure of performing a download depending on the use and location of the instrument. Depending on the needs and on national legal legislation it may be necessary for the user or owner of the measuring instrument to have to give his consent to a download.

3.7.7.2.7 If the requirements in 3.7.7.2.1 through 3.7.7.2.6 cannot be fulfilled, it is still possible to update the legally non-relevant software part. In this case the following requirements shall be met:

- there is a distinct separation between the legally relevant and non-relevant software,
- the whole legally relevant software part cannot be updated without breaking a seal,

it is stated in the type approval certificate that updating of the legally non-relevant part is acceptable.

### **3.7.8 Checking facility event record**

If the EVSE is equipped with a checking facility, the event record of the facility shall have room for at least 100 events (or an alternative number determined by the national authority) and shall be of a first-in-first-out type. It shall not be possible to change or zero the event record without breaking a seal and/or without authorised access, for example by means of a code (password) or of a special device (hard key, etc.).

### **3.7.9 Storage of data, transmission via communication systems**

#### **3.7.9.1 General**

If measurement values are used at another place than the place of measurement or at a later time than the time of measurement, they possibly have to leave the EVSE (electronic device, sub-assembly) and be stored or transmitted in an insecure environment before they are used for legal purposes. In this case the following requirements apply:

3.7.9.1.1 The measurement value stored or transmitted shall be accompanied by all relevant information necessary for future legally relevant use.

3.7.9.1.2 The legally relevant data shall be protected by software means to guarantee the authenticity, integrity and, if necessary, correctness of the information concerning the time of measurement. The software that displays or further processes the measurement values and accompanying data shall check the time of measurement, authenticity, and integrity of the data after having read them from the insecure storage or after having received them from an insecure transmission channel. If an irregularity is detected, the data shall be discarded or marked unusable.

Confidential keys employed for protecting data shall be kept secret and secured in the EVSE. Means shall be provided whereby these keys can only be input or read if a seal is broken.

3.7.9.1.3 Software modules that prepare data for storing or sending, or that check data after reading or receiving, belong to the legally relevant software part.

#### **3.7.9.2 Automatic storing**

3.7.9.2.1 When data storage is required, measurement data must be stored automatically when the measurement is concluded, i.e. when the final value has been generated. When the final value is from a calculation, all data that are necessary for the calculation must be automatically stored with the final value.

3.7.9.2.2 The storage device must have sufficient permanency to ensure that the data are not corrupted under normal storage conditions. There shall be sufficient memory storage for any particular application.

3.7.9.2.3 Stored data may be deleted if the transaction is settled.

Note: This shall not apply to the cumulative register and audit trail.

### **3.7.9.3 Data transmission**

3.7.9.3.1 The measurement shall not be inadmissibly influenced by a transmission delay.

3.7.9.3.2 If network services become unavailable, no legally relevant measurement data shall be lost.

### **3.7.9.4 Clock times**

Clock times used in transactions shall be accurate to  $\pm 60$  s with respect to legal time.

## **3.8 Durability**

The EVSE shall be designed to maintain an adequate stability of its metrological characteristics over a reverification period specified by the national authority or 5 years if none is specified, provided that it is properly installed, maintained and used according to the manufacturer's instructions when in the environmental conditions for which it is intended. The manufacturer shall provide evidence to support the durability claim.

The EVSE shall be designed to reduce as far as possible the effect of a defect that would lead to an inaccurate measurement result.

The EVSE shall be designed and manufactured such that either:

- a) Significant durability errors do not occur, or
- b) Significant durability errors are detected and acted upon by means of a durability protection.

## **3.9 Presumption of compliance**

The type of EVSE is presumed to comply with the provisions in Section 3 if it passes the examination and tests specified in Part 2 of this Guide.

## Part 2 Metrological controls and performance tests

### 4 Type approval

#### 4.1 Documentation

The documentation submitted with the application for type approval shall include:

- Identification of the type, including
  - name or trademark and type designation
  - version(s) of hardware and software
  - drawing of name plate
- Metrological characteristics of the EVSE, including
  - a description of the principle(s) of measurement
  - metrological specifications such as accuracy class and rated operating conditions (section 3.1)
  - any steps which should be performed prior to testing the EVSE;
- The technical specification for the EVSE, including
  - a block diagram with a functional description of the components and devices,
  - drawings, diagrams and general software information, explaining the construction and operation, including interlocks,
  - description and position of seals or other means of protection,
  - documentation related to durability characteristics,
  - any document or other evidence that the design and construction of the EVSE complies with the requirements of this Guide,
  - specified clock frequencies,
  - energy consumption of the EVSE.
- User manual.
- Installation manual
- A description of the checking facility for significant faults, if applicable.

In addition, software documentation shall include:

- a description of the legally relevant software and how the requirements are met:
  - list of software modules that belong to the legally relevant part including a declaration that all legally relevant functions are included in the description;
  - description of the software interfaces of the legally relevant software part and of the commands and data flows via this interface including a statement of completeness;
  - description of the generation of the software identification;
  - list of parameters to be protected and description of protection means;
- a description of security means of the operating system (password, etc. if applicable);
- a description of the (software) sealing method(s);
- an overview of the system hardware, e.g. topology block diagram, type of computer(s), type of network, etc.;
- where a hardware component is deemed legally relevant or where it performs legally relevant functions, this should also be identified;
- a description of the accuracy of the algorithms (e.g. filtering of A/D conversion results, price calculation, rounding algorithms, etc.);
- a description of the user interface, menus and dialogues;
- the software identification and instructions for obtaining it from an instrument in use;
- list of commands of each hardware interface of the measuring instrument / electronic device / sub-assembly including a statement of completeness;

- list of durability errors that are detected by the software and if necessary for understanding, a description of the detecting algorithms;
- a description of data sets stored or transmitted;
- if fault detection is realized in the software, a list of faults that are detected and a description of the detecting algorithm;
- the operating manual.

Furthermore, if the type approval is to be based on existing type test documentation, the application for type approval shall be accompanied by type test documents or other evidence that supports the assertion that the design and characteristics of the measuring instrument comply with the requirements of this Guide.

## 4.2 Type definition

EVSE produced by the same manufacturer may form a type provided they have similar metrological properties resulting from the use of the same uniform construction of parts/modules that determine the metrological properties.

A type may have several current ranges and several values of the nominal voltage and frequency, and include several connection modes and several ancillary devices.

Note: The same uniform construction normally means the same construction of the measuring elements, the same construction of metering software, the same construction of the register and indicating device, the same temperature compensation mechanism, the same construction of case, terminal block, and mechanical interface.

### 4.2.1 Type test sampling

The manufacturer shall provide at least as many specimens of the EVSE as are required by the national authority. The type test shall be made on one or more specimens of the EVSE, selected by the type test body, to establish its specific characteristics and to prove its conformity with the requirements of this Guide. In the case of modifications to the EVSE made after or during the type test and affecting only part of the EVSE, the issuing body may deem it sufficient to perform limited tests on the characteristics that may be affected by the modifications.

## 4.3 Validation Procedure

The validation procedure consists of a combination of analysis methods and tests as shown in Table 8. The abbreviations used are described in Table 9

**Table 8. Validation procedures for specified requirements.**

Requirement		Validation procedure
3.7.2	Software identification	AD + VFTSw
3.7.3.1	Prevention misuse	AD + VFTSw
3.7.3.2	Fraud protection	AD + VFTSw
3.7.4	Parameter protection	AD + VFTSw
3.7.5	Separation of electronic devices and sub-assemblies	AD
3.7.6	Separation of software parts	AD
3.7.9	Storage of data, transmission via communication systems	AD + VFTSw
3.7.9.1.2	Data protection with respect to time of measurement	AD + VFTSw
3.7.9.2	Automatic storing	AD + VFTSw
3.7.9.3.1	Transmission delay	AD + VFTSw
3.7.9.3.2	Transmission interruption	AD + VFTSw
3.7.9.4	Time stamp	AD + VFTSw
<b>Error! Reference source not found.</b>	Maintenance and re-configuration	AD

**Table 9 Validation procedure abbreviations**

Abbreviation	Description	OIML D 31:2008 Clause
AD	Analysis of the documentation and validation of the design	6.3.2.1
VFTSw	Validation by functional testing of software functions	6.3.2.3

## 5 Test program

Testing of EVSE is done using the same transactional process as is used in normal operation of the EVSE. This process consists of at least the following steps:

- 1) Initiating a charging session using the standard handshake exchange between the EVSE and a vehicle.
- 2) Charging at a specified power level for a specified quantity of energy (must be greater than the MMQ).
- 3) Terminate the transaction as would an electric vehicle.
- 4) Compare the energy delivered and transaction cost provided by the EVSE with the test equipment.

The initial intrinsic error shall be determined as the first test on the EVSE, as described in 6.2.1.

Power shall be applied to the EVSE for a period of 15 minutes before the start of testing

The order of the test points for initial intrinsic error shall be from lowest current to highest current and then from highest current to lowest current. For each test point, the resulting error shall be the mean of these measurements. In each case two times the minimum measured quantity of energy shall be delivered.

The determination of the initial intrinsic error (at reference conditions) shall always be carried out before tests of influence quantities and before disturbance tests that relate to a limit of error shift requirement or to a significant fault condition for error.

Otherwise, the order of tests is not prescribed in this Guide.

If an EVSE is specified for both single phase and three phase operation, then both configurations shall be tested.

National authorities may prescribe more stringent test regimes than those described in this section.

## 6 Test procedures for type approval

### 6.1 Test conditions

Unless otherwise stated in the individual test instructions, all influence quantities except for the influence quantity being tested shall be held at reference conditions as given by Table 10 during type approval tests.

**Table 10 Reference conditions and their tolerances**

Quantity	Reference conditions	Tolerance
Voltage(s)	$U_{\text{nom}}$	$\pm 1 \%$
Ambient temperature	$23^{\circ} \text{C}^{(1)}$	$\pm 2^{\circ}\text{C}$
Frequency AC EVSE DC EVSE	$f_{\text{nom}}$ $DC$	$\pm 0.3 \%$ $\text{ripple} \leq 2 \%$
Waveform ( $U$ and $I$ ) AC EVSE DC EVSE	Sinusoidal $DC$	$d \leq 2 \%$ $\text{ripple} \leq 2 \%$
Magnetic induction of external origin at reference frequency	0 T	$B \leq 0.05 \text{ mT}$
Electromagnetic RF fields 30 kHz to 6 GHz	0 V/m	$\leq 1 \text{ V/m}$

Operating position for instruments sensitive to position	Mounting as stated by manufacturer	$\pm 3.0^\circ$
Load balance (3-phase AC EVSE) <sup>(2)</sup>	Equal current in all current circuits	$\pm 2\%$
<p>(1) Tests may be performed at other temperatures if the results are corrected to the reference temperature by applying the temperature coefficient established in the type tests and provided an appropriate uncertainty analysis is carried out.</p> <p>(2) The requirement applies to both phase-to-phase and phase-neutral for poly-phase EVSE</p> <p>Note: The reference conditions and their tolerance are given to ensure reproducibility between testing laboratories, not to determine the accuracy of the tests. The demands on short term stability during test for influence factors may be much higher than shown in this table.</p>		

**Table 11. Load conditions and their tolerances in tests**

Quantity	Conditions	Tolerance
Current	Current range of device under test	Class A, B: $\pm 2\%$ Class C: $\pm 1\%$
Power factor (AC EVSE ONLY)	Power factor range of device under test	Current to voltage phase difference $\pm 2^\circ$

Note: The load conditions and their tolerance are given to ensure reproducibility between testing laboratories, not to determine the accuracy of the tests. The demands on short time stability during test for influence factors may be much higher than shown in this table.

For most tests, the measured power will be constant if the other influence quantities are kept constant at reference conditions. However, this is not possible for some tests such as influence of voltage variation and load unbalance. Therefore, the error shift shall always be measured as the shift of the relative error and not of the absolute power.

## 6.2 Tests for compliance with maximum permissible errors

### 6.2.1 Determination of initial intrinsic error

Object of the test: To verify that the error of the EVSE at reference conditions is less than the relevant BMPE. given in Table 2. Base maximum permissible errors.

Test Procedure: EVSE that are specified as being capable of bidirectional or unidirectional energy measurement as described in 3.3.2 shall meet the relevant BMPE. requirements of Table 2. Base maximum permissible errors for energy flow in both positive and negative directions.

Mandatory test points: Tests shall be conducted at unity power factor at  $I_{\min}$ ,  $I_{tr}$ ,  $50\% I_{\max}$  and  $I_{\max}$  for a delivered energy of at least the minimum measured quantity.

### 6.2.2 Self heating

Object of the test: To verify that the EVSE is able to carry  $I_{\max}$  continuously as specified in Table 4.

Test Procedure: The test shall be carried out as follows: The test shall be conducted for six hours or for the time required to deliver 60 kWh of energy whichever is shorter. The test shall be performed at  $I_{\max}$ .

The error shift compared to the intrinsic error shall comply with the requirements given in Table 4 Limit of error shift due to influence quantities.

### 6.2.3 Test of no-load condition

Object of the test: To verify the no-load performance of the EVSE given in 3.3.4.

Test Procedure: For this test, there shall be no current delivered to the load. The test shall be performed at  $U_{\text{nom}}$  for a duration of 10 minutes. No more than 1 Wh of energy shall be registered.

#### 6.2.4 Starting current

Object of the test: To verify that the EVSE starts and continues to operate at  $I_{st}$  as given by Table 1 Rated operating conditions.

Test Procedure: The EVSE shall be subjected to a current equal to the starting current  $I_{st}$  for a delivered energy of the minimum measured quantity. If the EVSE is designed for the measurement of energy in both directions, then this test shall be applied once with energy flowing in each direction. The effect of an intentional delay in measurement after reversal of energy direction should be taken into account when performing the test.

The EVSE shall register a minimum of 75% of the energy delivered.

Mandatory test points: The voltage shall be at the lowest  $U_{nom}$ .

### 6.3 Tests for influence quantities

#### 6.3.1 General

The purpose of these tests is to verify the requirements of section 3.3.3 due to the variation of a single influence quantity. For influence quantities listed in Table 4, it shall be verified that the error shift due to the variation of any single influence quantity is within the corresponding limit of error shift stated in Table 4 (See also the definition of maximum permissible error shift in 2.3.19).

All tests for AC EVSE are performed at PF = 1 unless stated otherwise. All tests for DC EVSE are performed with voltage and current ripple less than 2% unless stated otherwise.

#### 6.3.2 Temperature dependence

Object of the test: To verify that the temperature coefficient requirements of Table 3 are fulfilled.

Test Procedure: For each test point, the error of the EVSE shall be determined at each of the upper and lower ambient temperature limits specified for the EVSE, and at each of the temperatures from the following list in between:

-55 °C, -40 °C, -25 °C, -10 °C, +5 °C, +23 °C, +40 °C, +55 °C, +70 °C, +85 °C

Furthermore, for each pair of test points the temperature coefficient,  $c$ , shall be determined as follows:

$$c = \frac{e_u - e_l}{t_u - t_l}$$

where  $e_u$  and  $e_l$  are the errors at the upper and the lower temperatures respectively in the temperature interval of interest; and

$t_u$  and  $t_l$  are the upper and the lower temperatures respectively in the temperature interval of interest.

Each temperature coefficient must be in accordance with the requirements of Table 3.

Mandatory test points: The test shall, at minimum, be performed at a current of 50%  $I_{max}$ .

#### 6.3.3 Voltage variation

Object of the test: To verify that the error shift due to voltage variations complies with the requirements of Table 4.

#### AC EVSE

Test Procedure: The error shift, compared to the intrinsic error at  $U_{nom}$ , shall be measured when the voltage is varied within the corresponding rated operating range. For poly-phase EVSE, the test voltage shall be balanced.



**Mandatory test points:** If all  $U_{nom}$  are in the range 208V to 240V then tests shall be run at 200V and 250V. Otherwise, if several  $U_{nom}$  values are stated, the test shall be run at the 0.9 times the lowest  $U_{nom}$ , all  $U_{nom}$  and 1.1 times the highest  $U_{nom}$ . The test current shall be  $50\%I_{max}$ .

#### **DC EVSE (output voltage)**

**Test Procedure:** The error shift, compared to the intrinsic error at  $U_{nom}$ , shall be measured when the voltage is varied within the corresponding rated operating range.

**Mandatory test points:** For EVSE with  $U_{max} < 500$  V tests shall be performed at  $U_{max}$ ,  $80\% U_{max}$ , and  $60\% U_{max}$ . For EVSE with  $U_{max} \geq 500$  V additional test points at  $40\% U_{max}$  and  $20\% U_{max}$  shall be added.

#### **6.3.4 Frequency variation**

**Object of the test:** To verify that the error shift due to frequency variations complies with the requirements of Table 4.

**Test Procedure:** The error shift, compared to the intrinsic error at  $f_{nom}$ , shall be measured when the frequency is varied within the corresponding rated operating range. If several  $f_{nom}$  values are stated, the test shall be repeated with each  $f_{nom}$  value.

**Mandatory test points:** The test shall, at minimum, be performed at  $PF = 1$  for a current of  $50\%I_{max}$ , and at frequencies of  $(100+\Delta)\% f_{nom}$  and  $(100-\Delta)\% f_{nom}$ . This test may be omitted if  $\Delta$  specified by the national authority is less than 0.5%.

#### **6.3.5 Harmonics in voltage and current**

**Object of the test:** To verify that the error shift due to harmonics complies with the requirements for AC EVSE.

**Test Procedure:** The error shift, compared to the intrinsic error at sinusoidal conditions, shall be measured under each set of conditions described below.

Harmonic amplitudes are calculated relative to the amplitude of the fundamental frequency component of the voltage or current respectively. Phase angle is calculated relative to the zero-crossing of the fundamental frequency voltage or current component respectively.

**Mandatory test points:** The test shall, at minimum, be performed at  $50\% I_{max}$ ,  $PF = 1$ , where the power factor is given for the fundamental component.

**Test #1:** With a sinusoidal voltage of the highest  $U_{nom}$  and current of waveform EV#1 with a fundamental of  $50\% I_{max}$  measure the energy for a delivery of not less than MMQ.

The error shift shall not exceed that stated in Table 4.

**Test #2:** With voltage of waveform EV#1 with the fundamental equal to the highest  $U_{nom}$  and current of waveform EV#1 with a fundamental of  $50\%I_{max}$  measure the energy for a delivery of not less than MMQ.

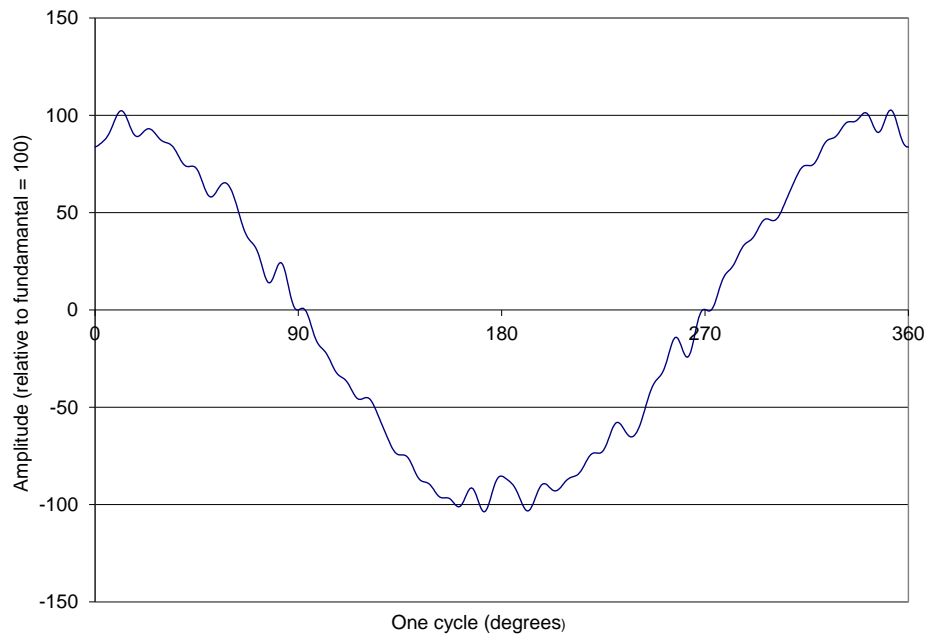
The error shift shall not exceed that stated in Table 4.

**Test #3:** With voltage waveform EV#2 with the fundamental equal to the highest  $U_{nom}$  and current waveform EV#1 with a fundamental of  $50\% I_{max}$  measure the accuracy for a delivery of not less than MMQ.

The error shift shall not exceed that stated in Table 4.

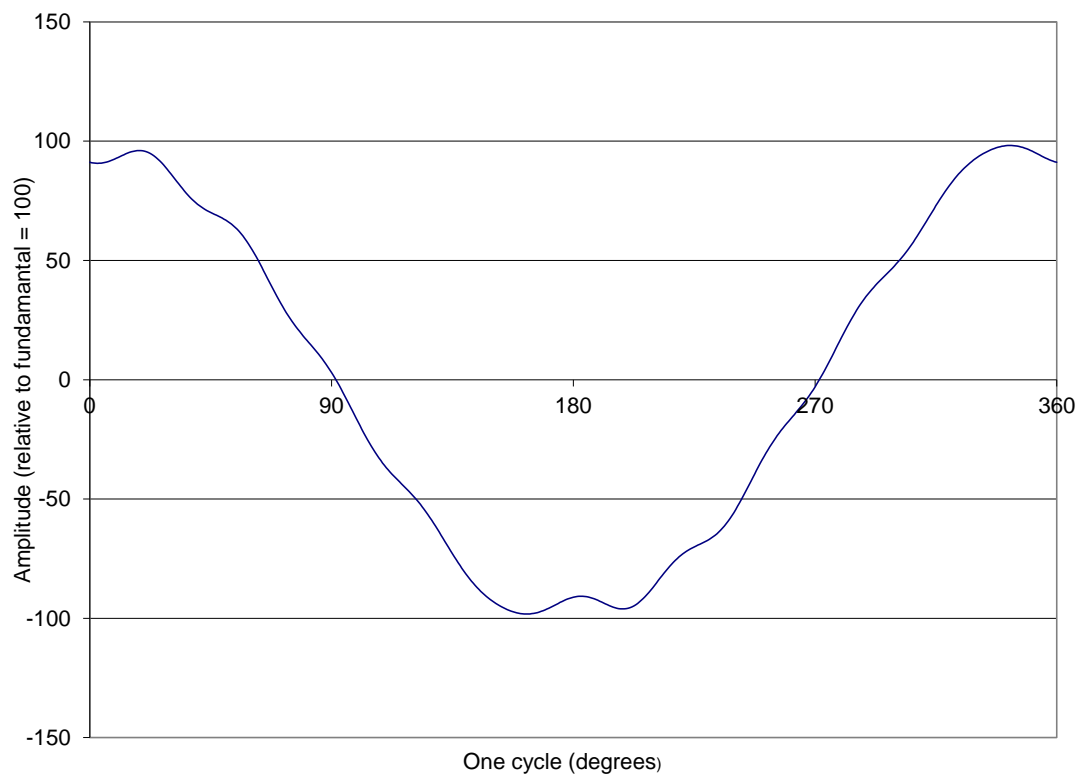
**Table 12 EV waveform #1**

Harmonic number	Amplitude (%)	Phase angle (°)	Harmonic number	Amplitude (%)	Phase angle (°)
1	100.00	0	2	0.25	188
3	3.00	217	4	0.20	150
5	2.40	212	6	0.16	232
7	2.28	159	8	0.15	205
9	2.16	143	10	0.14	165
11	2.05	254	12	0.00	-
13	1.95	95	14	0.00	-
15	1.85	188	16	0.00	-
17	1.76	266	18	0.00	-
19	1.67	168	20	0.00	-
21	1.59	216	22	0.00	-
23	1.51	247	24	0.00	-
25	1.43	240	26	0.00	-
27	1.36	120	28	0.00	-
29	1.29	239	30	0.00	-
31	1.23	29	32	0.00	-
33	1.17	133	34	0.00	-
35	1.11	59	36	0.00	-
37	1.05	135	38	0.00	-
39	1.00	370	40	0.00	-

**Figure 2 EV waveform #1**

**Table 13 EV waveform #2**

Harmonic number	Amplitude (%)	Phase (°)	Harmonic number	Amplitude (%)	Phase (°)
1	100	0	2	0.00	-
3	3.8	217	4	0.00	-
5	2.4	212	6	0.00	-
7	2.28	159	8	0.00	-
9	2.16	143	10	0.00	-
11	2.05	254	12	0.00	-
13	1.7	95	14	0.00	-
15	1.85	188	16	0.00	-
17	1.76	266	18	0.00	-
19	1.67	168	20	0.00	-
21	0.00	0.00	22	0.00	-
23	0.00	0.00	24	0.00	-
25	0.00	0.00	26	0.00	-
27	0.00	0.00	28	0.00	-
29	0.00	0.00	30	0.00	-
31	0.00	0.00	32	0.00	-
33	0.00	0.00	34	0.00	-
35	0.00	0.00	36	0.00	-
37	0.00	0.00	38	0.00	-
39	0.00	0.00	40	0.00	-

**Figure 3 EV waveform #2**

### 6.3.6 Reversed phase sequence (any two phases interchanged)

- Object of the test: To verify that the error shift due to interchanging any two of the three phases complies with the requirements of Table 4. This test only applies to three-phase meters.
- Test Procedure: The error shift, compared to the intrinsic error at reference conditions, shall be measured when any two of the three phases are interchanged.
- Mandatory test points: The test shall, at minimum, be performed at a reference current of 50 %  $I_{\max}$ , PF = 1 with any two of the three phases interchanged. Additional test points may be specified by national authorities.

### 6.3.7 Continuous (DC) magnetic induction of external origin

- Applicable standard: None.
- Object of the test: To verify that the error shift due to continuous (DC) magnetic induction of external origin complies with the requirements of Table 4.
- Test Procedure: The error shift, compared to the intrinsic error at reference conditions, shall be measured when the EVSE is subjected to continuous magnetic induction with a probe in the form of a permanent magnet with a surface area of at least 2000 mm<sup>2</sup>. The magnetic field along the axis of the magnet's core shall comply with details specified in Table 14 <sup>(1)</sup>.

Note (1): National authorities may select a lower magnetic induction for national requirements.

**Table 14. Specifications of the field along axis of the magnet's core**

Distance from magnet surface	Magnetic induction	Tolerance
30 mm	200 mT	±30 mT

- Mandatory test points: 6 points per EVSE surface. The test shall, at minimum, be performed at 50%  $I_{\max}$ . The greatest error shift is to be noted as the test result.

Note: Neodymium or niobium permanent magnets are recommended for this test.

### 6.3.8 Magnetic field (AC, power frequency) of external origin

- Applicable standard: IEC 61000-4-8.
- Object of the test: To verify that the error shift due to an AC magnetic field at power frequency complies with the requirements of Table 4.
- Test procedure in brief: The error shift, compared to the intrinsic error at reference conditions, shall be measured when the EVSE is exposed to a magnetic field at each  $f_{\text{nom}}$  under the most unfavourable condition of phase and direction.
- Test severity: Continuous field, 400 A/m.
- Mandatory test points: The test shall, at minimum, be performed at 50 %  $I_{\max}$ .

### 6.3.9 Electromagnetic fields

#### 6.3.9.1 Radiated, radio frequency (RF), electromagnetic fields

- Applicable standard: IEC 61000-4-3.
- Object of the test: To verify that the error shift due to radiated, radio frequency, electromagnetic fields complies with the requirements of Table 4.
- Test Procedure in brief: The error shift, compared to the intrinsic error at sinusoidal conditions, shall be measured when the EVSE is subjected to electromagnetic RF fields. The electromagnetic field strength shall be as specified by the severity level and the field uniformity shall be as defined by the standard referenced. The frequency ranges to

be considered are swept with the modulated signal, pausing to adjust the RF signal level or to switch oscillators and antennas as necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value. The test time for a 1 % frequency change shall not be less than the time to make a measurement and in any case not less than 0.5 seconds.

The cable length exposed to the electromagnetic field shall be 1 m.

The test shall be performed with the generating antenna facing each side of the EVSE. When the EVSE can be used in different orientations (i.e. vertical or horizontal) all sides shall be exposed to the fields during the test.

The carrier shall be modulated with 80 % AM at 1 kHz sine wave.

The EVSE shall be separately tested at the manufacturer's specified clock frequencies.

Any other sensitive frequencies shall also be analysed separately.

Note: Usually these sensitive frequencies can be expected to be the frequencies emitted by the EVSE.

Test Condition: During the test, the EVSE shall be energized with reference voltage and a current equal to 50% $I_{max}$ . The measurement error of the EVSE shall be monitored by comparison with a reference standard not exposed to the electromagnetic field or immune to the field, or by an equally suitable method. The error at each 1% incremental interval of the carrier frequency shall be monitored and compared to the requirements of Table 4. When using a continuous frequency sweep, this can be accomplished by adjusting the ratio of the sweep time and the time of each measurement. When using incremental 1% frequency steps, this can be accomplished by adjusting the dwell time on each frequency to fit the measurement time.

Test severities: 80 MHz to 6000 MHz at a field strength of 30 V/m.

#### **6.3.9.2 Immunity to Conducted Disturbances, Induced by Low Frequency Fields**

Applicable standard:

Object of the test:

Test procedure in brief:

Test severity:

Frequency range:

#### **6.3.9.3 Immunity to Conducted Disturbances, Induced by Radiofrequency Fields**

Applicable standard: IEC 61000-4-6.

Object of the test: To verify that the error shift due to conducted disturbances, induced by RF fields complies with the requirements of Table 4.

Test procedure in brief: A radiofrequency electromagnetic current to simulate the influence of electromagnetic fields shall be coupled or injected into the power ports and I/O ports of the EVSE using coupling/decoupling devices as defined in the standard referenced. The performance of the test equipment consisting of an RF generator, (de)coupling devices, attenuators, etc. shall be verified.

The EVSE shall be tested as a tabletop instrument. During the test, the EVSE shall be energized with reference voltage and a current equal to 50% $I_{max}$ . The error at each 1% incremental interval of the carrier frequency shall be monitored and compared to the requirements of Table 4. When using a continuous frequency sweep, this can be accomplished by adjusting the ratio of the sweep time and the

time of each measurement. When using incremental 1% frequency steps, this can be accomplished by adjusting the dwell time on each frequency to fit the measurement time. The test time for a 1 % frequency change shall not be less than the time to make a measurement and in any case not less than 0.5 seconds.

If the EVSE is a poly-phase EVSE, the tests shall be performed at all extremities of the cable.

Test severity: RF amplitude (50  $\Omega$ ): 10 V (e.m.f.)

Frequency range: 0.15 MHz to 80 MHz

Modulation: 80 % AM, 1 kHz sine wave

### 6.3.10 Operation of ancillary devices

Object of the test: To verify compliance with the provisions of Table 4 under conditions of operation of ancillary devices. The operation of ancillary devices shall be tested to ensure that they do not affect the metrological performance of the EVSE.

Test Procedure: In this test, the EVSE shall be operated at reference conditions and its error continuously monitored, while ancillary devices such as communication devices, relays and other I/O circuits are operated.

Allowed effects: The functionality of the EVSE shall not be impaired and the error shift due to the operation of the ancillary devices shall always be less than the error shift limit specified in Table 4.

Mandatory test point: 50%  $I_{\max}$ .

## 6.4 Tests for disturbances

### 6.4.1 General instructions for disturbance tests

These tests are to verify that the EVSE fulfils the requirements for the influence of disturbances as given by Table 5, Table 6 and Table 7. Tests are to be performed using one disturbance at a time; all other influence quantities shall be set to reference conditions unless otherwise stated in the relevant test description. No significant fault shall occur. Unless otherwise stated, each test shall confirm by measurement that the EVSE still fulfils the base maximum permissible error requirements after the disturbance test.

Temporary loss of functionality is allowed as long as the EVSE returns to normal functionality automatically when the disturbance is removed.

The mandatory test point for the check of base maximum permissible error is 50%  $I_{\max}$ , PF = 1.

### 6.4.2 Electrostatic discharge

Applicable standard: IEC 61000-4-2.

Object of the test: To verify compliance with the requirements of 3.3.6.2 and Table 5 under conditions of direct and indirect electrostatic discharge.

Test procedure in brief: An ESD generator shall be used with performance characteristics specified in the referenced standard. Before starting the tests, the performance of the generator shall be verified. At least 10 discharges, in the most sensitive polarity, shall be applied. For a EVSE not equipped with a ground terminal, the EVSE shall be fully discharged between discharges. Contact discharge is the preferred test method. Air discharges shall be used where contact discharge cannot be applied.

Direct application: In the contact discharge mode to be carried out on conductive surfaces, the electrode shall be in contact with the EVSE. In the air discharge mode on insulated surfaces, the electrode is approached to the EVSE and the discharge occurs by spark.

Indirect application: The discharges are applied in the contact mode to coupling planes mounted in the vicinity of the EVSE.

- Test #1: A transaction shall be performed at  $U_{nom}$  and  $50\%I_{max}$  for a sufficient quantity of energy to allow all of the discharges to be applied.  
Apply the discharges during the transaction.
- Allowed effects: No significant fault shall occur. If the transaction is interrupted by the discharges, it shall be terminated without billing of the customer.
- Test #2: After Test #1 is completed, a transaction shall be performed at  $U_{nom}$  and  $50\%I_{max}$  for a delivery of at least the MMQ of energy.
- Allowed effects: An error shift larger than 1.0 BMPE constitutes shall not occur.
- Test severity: Contact discharge voltage (1): 8 kV  
Air discharge voltage (2): 15 kV  
Note (1): Contact discharges shall be applied on conductive surfaces.  
Note (2): Air discharges shall be applied on non-conductive surfaces.
- Performance verification: Accuracy test.
- Mandatory test points:  $50\%I_{max}$
- Allowed effects: Error shift less than 1.0 BMPE.

#### 6.4.3 Fast transients

- Applicable standards: IEC 61000-4-1, IEC 61000-4-4.
- Object of the test: To verify compliance with the requirements of 3.3.6.2 and Table 5 under conditions where electrical bursts are superimposed on voltage and current circuits, and I/O and communication ports.
- Test procedure in brief: A burst generator shall be used with the performance characteristics specified in the referenced standard. The EVSE shall be subjected to bursts of voltage spikes for which the repetition frequency of the impulses and peak values of the output voltage on 50 Ohm and 1000 Ohm loads are defined in the referenced standard. The characteristics of the generator shall be verified before connecting the EVSE. Both positive and negative polarity bursts shall be applied. The duration of the test shall not be less than 1 min for each amplitude and polarity. A capacitive coupling clamp, as defined in the standard, shall be used to couple to I/O and communication lines with a reference voltage over 40 V. The test pulses shall be applied continuously during the measurement time.
- Test conditions: The EVSE voltage and auxiliary circuits shall be energised with reference voltage  
The cable length between the coupling device and the EVSE shall be 1 m.  
The test voltage shall be applied in common mode (line-to-earth) to:  
the input power circuits;  
the auxiliary circuits, if separated from the voltage circuits in normal operation and with a reference voltage over 40 V.
- Test severity: Test voltage on the input power circuits: 2 kV.  
Test voltage on auxiliary circuits with a reference voltage over 40 V: 1 kV.

Performance verification: Accuracy test.

- Mandatory test points:  $50\%I_{max}$
- Allowed effects: Error shift less than 1.0 BMPE.

#### 6.4.4 Voltage dips and interruptions

- Applicable standards: IEC 61000-4-11, IEC 61000-6-1, IEC 61000-6-2.

Object of the test: To verify compliance with the requirements of 3.3.6.2 and Table 5 under conditions of short time mains voltage reductions (dips and interruptions).

Test procedure in brief: A test generator, which is able to reduce the amplitude of the AC mains voltage over an operator-defined period of time, should be used in this test. The performance of the test generator shall be verified before connecting the EVSE.

The mains voltage reductions shall be repeated 10 times with an interval of at least 10 seconds.

Test conditions: Perform during a transaction with voltage circuits initially energized with  $U_{nom}$  and no current flowing. If the EVSE shuts down at any point during either test that test is considered complete.

Test severities: Voltage dips:

Test	Test a	Test b	Test c
Reduction:	to 30 % $U_{nom}$	to 60 % $U_{nom}$	to 60 % $U_{nom}$
Duration:	0.5 cycles	1 cycle	25 cycles (50 Hz) 30 cycles (60 Hz)

Voltage interruption test:

Reduction:	to 0 % $U_{nom}$
Duration:	250 cycles (50 Hz) 300 cycles (60 Hz)

Allowed effect: The transaction shall terminate when the EVSE shuts down. The transaction shall be cancelled with no charge to the customer.

Performance verification: Accuracy test.

Mandatory test points: 50%  $I_{max}$

Allowed effects: Error shift less than 1.0 BMPE.

#### 6.4.5 Surges on AC mains power lines

Applicable standard: IEC 61000-4-5.

Object of the test: To verify compliance with the requirements of 3.3.6.2 and Table 5 under conditions where electrical surges are superimposed on the mains voltage and, if applicable, on I/O and communication ports.

Test procedure in brief: A surge generator shall be used with the performance characteristics specified in the referenced standard. The test consists of exposure to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load, and minimum time interval between two successive pulses are defined in the referenced standard.

The characteristics of the generator shall be verified before connecting the EVSE.

Test conditions: EVSE in operating condition;

- voltage circuits energized with nominal voltage;
- without any current in the current circuits and the current terminals shall be open;
- cable length between surge generator and EVSE: 1 m;
- tested in differential mode (line to line);



- phase angle: pulses to be applied at 60° and 240° relative to zero crossing of AC supply;

Test severities:

Voltage circuits:

Line to line: Test voltage: 1.0 kV, generator source impedance: 2 Ω

Line to earth<sup>(1)</sup>: Test voltage: 2.0 kV, generator source impedance: 2 Ω

Number of tests: 5 positive and 5 negative

Repetition rate: maximum 1/min.

Auxiliary circuits with a reference voltage over 40 V:

Line to line: Test voltage 1.0 kV, generator source impedance 42 Ω

Line to earth<sup>(1)</sup>: Test voltage 2.0 kV, generator source impedance 42 Ω

Number of tests: 5 positive and 5 negative

Repetition rate: maximum 1/min.

(1): For cases where the earth of the EVSE is separate to neutral.

Performance verification: Accuracy test.

Mandatory test points: 50%  $I_{\max}$

Allowed effects: Error shift less than 1.0 BMPE.

#### 6.4.6 Short-time overcurrent

Object of the test: To verify compliance with the requirements of 3.3.6.2 and Table 5 under conditions of a short time overcurrent.

Test procedure in brief: The EVSE shall be able to handle the current caused by a short-circuit within the electric vehicle, when the EVSE is protected with the proper fuses or breakers.

Test current: A current equivalent to  $5 \cdot I_{\max}$  (+0 %, -10%), for 0.5 cycle.

The test current shall be applied to one phase at the time. The test current value given is the RMS value, not the peak value.

Allowed effects: No damage shall occur. With the voltage reconnected the EVSE shall be allowed to return to normal temperatures (about one hour). The error shift, compared to the initial error before the test, shall then be less than the limit of error shift given by Table 5.

Performance verification: Accuracy test.

Mandatory test points: 50%  $I_{\max}$

Allowed effects: Error shift less than 1.0 BMPE.

#### 6.4.7 Impulse voltage

##### 6.4.7.1 General

Object of the test: To verify compliance with the requirements of 3.3.6.2 and Table 5 under conditions of impulse voltage.

General test procedure: The EVSE and its incorporated ancillary devices, if any, shall be such that they retain adequate dielectric qualities, taking account of the atmospheric influences and different voltages to which they are subjected under normal conditions of use.

The EVSE shall withstand the impulse voltage test as specified below. The test shall be carried out only on complete EVSE.

For the purpose of this test, the term “earth” has the following meaning:

when the EVSE case is made of metal, the “earth” is the case itself, placed on a flat, conducting surface;

when the EVSE case or only part of it is made of insulating material, the “earth” is a conductive foil wrapped around the EVSE touching all accessible conductive parts and connected to the flat, conducting surface on which the EVSE is placed. The distances between the conductive foil and the terminals, and between the conductive foil and the holes for the conductors, shall be no more than 2 cm.

During the impulse voltage test, the circuits that are not under test shall be connected to the earth.

General test conditions: ambient temperature: 15 °C to 25 °C;  
relative humidity: 25 % to 75 %;  
atmospheric pressure: 86 kPa to 106 kPa.

Allowed effects: No significant fault. No damage shall occur.

Performance verification: Accuracy test.

Mandatory test points: 50%  $I_{\max}$

Allowed effects: Error shift less than 1.0 BMPE.

#### 6.4.7.2 Impulse Voltage Test Procedure

Test Conditions: impulse waveform: 1.2/50  $\mu$ s impulse specified in IEC 60060-1;  
voltage rise time:  $\pm 30$  %;  
voltage fall time:  $\pm 20$  %;  
source energy: 10.0 J  $\pm$  1.0 J;  
test voltage: in accordance with Table 15;  
test voltage tolerance: +0 –10 %.

Note: The selection of the source impedance is at the discretion of the testing laboratory.

For each test (see 6.4.7.3 and 6.4.7.4) the impulse voltage is applied ten times with one polarity and then repeated ten times with the other polarity. The minimum time between impulses shall be 30 seconds.

**Table 15 Impulse voltage test levels**

Voltage phase to earth derived from rated system voltage ( $U$ )	Rated impulse voltage ( $U$ )
$100 \text{ V} \leq U < 150 \text{ V}$	1 500 V
$150 \text{ V} \leq U < 300 \text{ V}$	2 500 V
$300 \text{ V} \leq U < 600 \text{ V}$	4 000 V
Note: The above comply with IEC 61010-1 Level III National authority may change the applicable rated impulse voltage levels.	

Allowed effects: No significant fault. No damage shall occur.

Performance verification: Accuracy test.

Mandatory test points: 50%  $I_{\max}$

Allowed effects: Error shift less than 1.0 BMPE.

### 6.4.7.3 Impulse voltage tests for circuits and between circuits

**Test Procedure:** The test shall be made independently on each circuit (or assembly of circuits) which is insulated from other circuits of the EVSE in normal use. The terminals of the circuits which are not subjected to impulse voltage shall be connected to earth.

Thus, when the voltage and current circuits of a measuring element are connected together in normal use, the test shall be made on the whole. The other end of the voltage circuit shall be connected to earth and the impulse voltage shall be applied between the terminal of the current circuit and earth. When several voltage circuits of a EVSE have a common point, this point shall be connected to earth and the impulse voltage successively applied between each of the free ends of the connections (or the current circuit connected to it) and earth. The other end of this current circuit shall be open.

When the voltage and current circuits of the same measuring element are separated and appropriately insulated in normal use (e.g. each circuit connected to measuring transformer), the test shall be made separately on each circuit.

During the test of a current circuit, the terminals of the other circuits shall be connected to earth and the impulse voltage shall be applied between one of the terminals of the current circuit and earth. During the test of a voltage circuit, the terminals of the other circuits and one of the terminals of the voltage circuit under test shall be connected to earth and the impulse voltage shall be applied between the other terminal of the voltage circuit and earth.

The auxiliary circuits intended to be connected either directly to the mains or to the same voltage transformers as the EVSE circuits, and with a reference voltage over 40 V, shall be subjected to the impulse voltage test by being tied together with a voltage circuit during tests. The other auxiliary circuits shall not be tested.

**Allowed effects:** No significant fault. No damage shall occur.

**Performance verification:** Accuracy test.

**Mandatory test points:**  $50\%I_{\max}$

**Allowed effects:** Error shift less than 1.0 BMPE.

### 6.4.7.4 Impulse voltage test of electric circuits relative to earth

**Test procedure:** All the terminals of the electric circuits of the EVSE, including those of the auxiliary circuits with a reference voltage over 40 V, shall be connected together.

The auxiliary circuits with a reference voltage below or equal to 40 V shall be connected to earth. The impulse voltage shall be applied between all the electric circuits and earth.

**Allowed effects:** No significant fault. No flashover, disruptive discharge or puncture shall occur.

**Performance verification:** Accuracy test.

**Mandatory test points:**  $50\%I_{\max}$

**Allowed effects:** Error shift less than 1.0 BMPE.

## 6.4.8 Environmental tests

Tests 6.4.8.1 through 6.4.8.6 comprise a suite of tests for immunity to various environmental disturbances. All tests are performed with the EVSE unpowered. Tests may be performed in any order. All tests in 6.4.8 may be performed as a group with a single accuracy test before and after the group of tests.

### 6.4.8.1 Protection against solar radiation

**Applicable standard:** ISO 4892-3

The object of the test: To verify compliance with the requirements of 3.3.6.3, 3.4, 3.7.1 and Table 6 regarding protection against solar radiation. For outdoor EVSE only.

Test conditions: EVSE in non-operating condition;

Test apparatus: Lamp type/wavelength: UVA 340

Black panel thermometer

Light meter

Cycling rig with a condensation cycle to comply with the parameters in the test conditions

Test conditions: EVSE in non-operating condition

Test Cycle (12 h cycle)	Lamp type	Spectral irradiance	Black panel temperature
8 h dry	UVA 340	0.76 W/m <sup>2</sup> /nm at 340 nm	(60 ±3) °C
4 h condensation		Light off	(50 ±3) °C

Test Procedure in brief: Partially mask a section of the EVSE for later comparison. Expose the EVSE to artificial radiation and weathering in accordance with ISO 4892-3 for a period of 66 days (132 cycles) and in accordance with the test conditions above.

Allowed effects: After the test the EVSE shall be visually inspected and a functional test shall be performed. The appearance and, in particular, the legibility of markings and displays shall not be altered. Any means of protection of the metrological properties, such as the case and sealing, shall not be affected. The function of the EVSE shall not be impaired.

#### 6.4.8.2 Protection against ingress of dust

Applicable standard: IEC 60529

The object of the test: To verify compliance with the provisions of 3.3.6.2 and Table 6 regarding protection against the ingress of dust.

Test conditions: Reference conditions,

IP 54 rating.

Category 2 enclosure.

Test procedure in brief: After the test the interior of the EVSE shall be visually inspected and a functional test shall be performed.

Allowed effects: The talcum powder or other dust used in the test shall not have accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety. No dust shall deposit where it could lead to tracking along the creepage distances. The function of the EVSE shall not be impaired.

#### 6.4.8.3 Extreme temperatures - dry heat

Applicable standards: IEC 60068-2-2, IEC 60068-3-1.

Object of the test: To verify compliance with the provisions of 3.3.6.2 and Table 6 under conditions of dry heat.

Test procedure in brief: The test consists of exposure to the specified high temperature under “free air” conditions for 2 hours (beginning from when the temperature of the EVSE is stable), with the EVSE in a non-operating state.

The change of temperature shall not exceed 1 °C/min during heating up and cooling down.

The absolute humidity of the test atmosphere shall not exceed 20 g/m<sup>3</sup>.

Test severity: The test shall be performed at a standard temperature one step higher than the upper temperature limit specified for the EVSE.

Possible temperatures: 40 °C, 55 °C, 70 °C, 85 °C

Allowed effects: After the test, the function of the EVSE shall not be impaired and the error shift shall not exceed the limit of error shift listed in 3.3.6.3.

Mandatory test points: 50%  $I_{max}$ , PF = 1.

#### 6.4.8.4 Extreme temperatures - cold

Applicable standards: IEC 60068-2-1, IEC 60068-3-1.

Object of the test: To verify compliance with the provisions of 3.3.6.2 and Table 5 under conditions of low temperatures.

Test procedure in brief: The test consists of exposure to the specified low temperature under “free air” conditions for 2 hours (beginning from the time when the temperature of the EVSE is stable) with the EVSE in a non-operating state.

The change of temperature shall not exceed 1 °C/min during heating up and cooling down.

Test severity: The test shall be performed at a standard temperature one step lower than the lower temperature limit specified for the EVSE.

Possible temperatures: -10 °C, -25 °C, -40 °C, -55 °C <sup>(1)</sup>

Allowed effects: After the test, the function of the EVSE shall not be impaired and the error shift shall not exceed the limit of error shift listed in Table 6.

Mandatory test points: 50%  $I_{max}$ , PF = 1.

Note (1) If specified lower temperature limit is -55 °C, then this test shall be performed at -55 °C.

#### 6.4.8.5 Damp heat, steady-state (non-condensing), for humidity class H1

Applicable standards: IEC 60068-2-78, IEC 60068-3-4.

Object of the test: To verify compliance with the provisions in 3.3.6.2 and Table 6 under conditions of high humidity and constant temperature. For EVSE that are specified for enclosed locations where the EVSE are not subjected to condensed water, precipitation, or ice formations (H1).

Test procedure in brief: The test consists of exposure to the specified high level temperature and the specified constant relative humidity for a certain fixed time defined by the severity level. The EVSE shall be handled such that no condensation of water occurs on it.

Test conditions: Voltage and auxiliary circuits energized with reference voltage;  
Without any current in the current circuits.

Test severity: Temperature: 30 °C

Humidity: 85 %

Duration: 2 days

Allowed effects: During the test no significant fault shall occur. Immediately after the test the EVSE shall operate correctly and comply with the accuracy requirements of Table 6

24 hours after the test the EVSE shall be submitted to a functional test during which it shall be demonstrated to operate correctly. There shall be no evidence of any mechanical damage or corrosion which may affect the functional properties of the EVSE.

#### 6.4.8.6 Damp heat, cyclic (condensing) for humidity classes H2 and H3

Applicable standards: IEC 60068-2-30, IEC 60068-3-4.

Object of the test: To verify compliance with the requirements in 3.3.6.2 and Table 6 under conditions of high humidity and temperature variations. This test applies to EVSE with a humidity class specification either for enclosed locations where EVSE can be subjected to condensed water or for open locations (humidity classes H2 and H3).

Test procedure in brief: The test consists of exposure to cyclic temperature variation between 25 °C and the temperature specified as the upper temperature according to the test severities below, whilst maintaining the relative humidity above 95 % during the temperature change and low temperature phases, and at 93 % during the upper temperature phases. Condensation should occur on the EVSE during the temperature rise.

The 24 h cycle consists of:

- a) temperature rise during 3 h
- b) temperature maintained at upper value until 12 h from the start of the cycle
- c) temperature reduced to lower value within 3 h to 6 h, the rate of fall during the first hour and a half being such that the lower value would be reached in 3 h
- d) temperature maintained at lower value until the 24 h cycle is completed.

The stabilizing period before and recovery after the cyclic exposure shall be such that all parts of the EVSE are within 3 °C of their final temperature.

Test conditions: Voltage and auxiliary circuits energized with reference voltage;

Without any current in the current circuits.

Mounting position according to manufacturer's specification

Test severities: EVSE with a humidity class specification for enclosed locations where EVSE can be subjected to condensed water shall be tested at severity level 1. EVSE with a humidity class specification for open locations shall be tested at severity level 2.

Specified Humidity Class:	H2	H3
Severity levels:	1	2
Upper temperature (°C):	40	55
Duration (cycles):	2	2

Allowed effects: During the test no significant fault shall occur.

Immediately after the test the EVSE shall operate correctly and comply with the accuracy requirements of Table 4.

24 hours after the test, the EVSE shall be submitted to a functional test during which it shall be demonstrated to operate correctly. There shall be no evidence of any mechanical damage or corrosion which may affect the functional properties of the EVSE.

#### 6.4.8.7 Water test

Applicable standards: IEC 60068-2-18, IEC 60512-14-7, IEC 60529

Object of the test: To verify compliance with the requirements in 3.3.6.2 and Table 6 under conditions of rain and water splashes. The test is applicable to EVSE that are specified for open locations (H3).

Test procedure in brief: The EVSE is mounted on an appropriate fixture and is subjected to impacting water generated from either an oscillating tube or a spray nozzle used to simulate spraying or splashing water.

Test conditions: The EVSE shall be in functional mode during the test

Flow rate (per nozzle): 0.07 L/min

Duration: 10 min

Angle of inclination: 0 ° and 180 °

Allowed effects: During the test no significant fault shall occur.

Immediately after the test the EVSE shall operate correctly and comply with the accuracy requirements of Table 6.

24 hours after the test the EVSE shall be submitted to a functional test during which it shall be demonstrated to operate correctly and comply with the accuracy requirements of Table 2. Base maximum permissible errors. There shall be no evidence of any mechanical damage or corrosion which may affect the functional properties of the EVSE.

#### 6.4.9 Durability test

Object of the test: To verify compliance with the provisions in 3.8 and Table 6 for durability.

Test procedure in brief: The test procedure for durability shall subject a number of EVSE to the conditions below. The EVSE accuracy shall be determined prior to and after the durability test.

Test conditions: A minimum of 1 EVSE.

Test temperature: 70 °C, dry heat.

Test voltage: 110% of highest nominal voltage supply voltage.

Test load: 50%  $I_{\max}$  but not exceeding 50 kW.

Test duration: 1000 hours.

Mandatory test points: For initial and final measurement, the voltage shall be  $U_{\text{nom}}$ , with the following test points:  $I_{\text{tr}}$  and 50%  $I_{\max}$  at PF = 1.

Note: National authorities may accept MTBF calculations or other reliability data from manufacturers in lieu of this test.

#### 6.4.10 Mechanical tests

All tests in 6.4.10 may be performed as a group with a single accuracy test before and after the group of tests. National authorities may eliminate any of these tests when the EVSE is too large to perform the test reasonably and at a reasonable cost. These tests may also be eliminated from type approval if *in situ* testing is performed prior to an EVSE being put into service.

##### 6.4.10.1 Vibrations

Applicable standards: IEC 60068-2-47, IEC 60068-2-64.

Object of the test: To verify compliance with the provisions of 3.3.6.2 and Table 7 under conditions of vibrations.

Test procedure in brief: The EVSE shall, in turn, be tested in three, mutually perpendicular axes whilst mounted on a rigid fixture by its normal mounting means.

The EVSE shall normally be mounted so that the gravitational force acts in the same direction as it would in normal use. Where the effect of gravitational force is not important the EVSE may be mounted in any position.

Test severity:

Total frequency range	10 Hz to 150 Hz
Total RMS level	7 m·s <sup>-2</sup>
Acceleration Spectral Density (ASD) level 10-20 Hz	1 m <sup>2</sup> ·s <sup>-3</sup>
Acceleration Spectral Density (ASD) level 20-150 Hz	-3 dB/octave
Duration per axis:	at least 2 minutes.

Mandatory test points: 50%  $I_{\max}$

Allowed effects: After the test, the function of the EVSE shall not be impaired and the error shift, at  $50\%I_{\max}$ , shall not exceed 1.0 BMPE.

#### **6.4.10.2 Shock**

Applicable standard: IEC 60068-2-27.

Object of the test: To verify compliance with the provisions of 3.3.6.2 and Table 7 under conditions of shock.

Test procedure in brief: The EVSE is subjected to non-repetitive shocks of standard pulse shapes with specified peak acceleration and duration. During the test, the EVSE shall not be operational and it shall be fastened to a fixture or to the shock-testing machine.

Test severity: Pulse shape: Half-sine

Peak acceleration:  $30 g_n$

Pulse duration: 18 ms

Allowed effects: No significant fault. Function of the EVSE shall not be impaired.

Performance verification: Accuracy test.

Mandatory test points:  $50\%I_{\max}$

Allowed effects: Error shift less than 1.0 BMPE.

### **7 Examination for conformity with type**

An examination for conformity with type should determine whether a EVSE complies with all requirements in section 3, and whether documentation supplied by the manufacturer complies with the requirements in section 4.1.

A EVSE may only be deemed to have passed examination for conformity with type if the results of all type tests comply with the requirements given in section 3. The measurement uncertainty must be small enough to allow clear discrimination between a pass result and a fail result. In particular, an uncertainty less than one fifth the maximum permissible error given for the corresponding test point must be obtained for tests described in section 6.2, unless otherwise specified in the relevant test description.

The scope of the tests performed and test severities used shall be consistent with the manufacturer's specifications and with the requirements of section 3.

### **8 Verification and re-verification**

#### **8.1 General**

Verification may be carried out either individually or statistically. In all cases EVSE shall conform to the requirements of this Guide. As noted in 3.3.3, national authorities may specify the base maximum permissible errors for subsequent verification and re-verification. The following minimum programme applies to the initial verification of all EVSE, whether verified individually or statistically, and to re-verification of EVSE which have been repaired or otherwise changed. For individual or statistical re-verification of EVSE that have not been repaired or otherwise changed, the programme may be modified and further reduced.

The exact requirements for verification and re-verification <sup>(1)</sup> shall be specified by the national authority.

#### **8.2 Testing**

##### **8.2.1 Calibration status**

Check that the test system used has sufficient accuracy to verify the EVSE under test, and that the calibration is valid.

##### **8.2.2 Conformity check**

Check that the instrument is manufactured in conformity with the type approval documentation.



### 8.2.3 Warming-up

It may be necessary to warmup the EVSE up before full operation. The length of the warmup period depends on the actual type of EVSE and shall be determined in advance. The order of the test points shall be from lowest current to highest current and then from highest current to lowest current. For each test point, the resulting error shall be the mean of these measurements.

### 8.2.4 Minimum test programme

The minimum programme consists of:

Starting current check

Current dependence

#### 8.2.4.1 Starting current check

The test is performed at  $I_{st}$ .

The requirement is that the EVSE register at least 75% of the energy delivered (refer to the test procedure in 6.2.4).

If an AC EVSE can operate in both single phase and three phase modes, then both modes shall be tested.

#### 8.2.4.2 Current dependence

EVSE shall comply with the accuracy requirements of Table 2. Base maximum permissible errors. As a minimum these shall be checked at the following currents:

$$I_{min}, \quad I_{tr}, \quad 50\% I_{max}, \quad I_{max}$$

If an EVSE can operate in both single phase and three phase modes, then both modes shall be tested.

For EVSE operating at a voltage within 208V to 240V, testing may be done at any  $U_{nom}$  within the range. Otherwise, tests shall be run at the lowest  $U_{nom}$  and the highest  $U_{nom}$ .

### 8.2.5 Sealing

If there are no seals on the EVSE (e.g. because they have not yet been applied or because they have been removed during verification testing), the EVSE shall be sealed in accordance with the requirements specified by national authorities.

## 8.3 Reference conditions for initial and subsequent verifications in a laboratory

Reference conditions and load conditions for initial and subsequent verifications in a laboratory are given in Table 16 and Table 17. National authorities may specify tighter tolerances.

**Table 16 Reference conditions and their tolerances for initial and subsequent verification**

Quantity	Reference conditions	Tolerance
Voltage(s)	$U_{nom}$	$\pm 2 \%$
Ambient temperature	23°C	$\pm 5^{\circ}\text{C}$
Frequency	$f_{nom}$	$\pm 0.5 \%$
Wave-form	Sinusoidal	$d \leq 2 \%$
Magnetic induction of external origin at reference frequency	0 T	$B \leq 0.1 \text{ mT}$
Electromagnetic RF fields 30 kHz - 6 GHz	0 V/m	$< 2 \text{ V/m}$
Phase sequence for poly-phase EVSE	L1, L2, L3	-
Load balance	Equal current in all current circuits	$\pm 5 \%$ and $\pm 5^{\circ}$

**Table 17 Load conditions and their tolerances in tests for initial and subsequent verification**

Current(s)	Current range of device under test	Class A, B: $\pm 10\%$ Class C: $\pm 10\%$
Power factor	Power factor range of device under test	current to voltage phase difference $\pm 5^\circ$

#### 8.4 Additional requirements for statistical verifications

This section contains additional requirements for verification on a statistical basis.

Note: National authorities shall determine whether the use of statistical methods is permitted.

##### 8.4.1 Lot

A lot shall consist of EVSE with homogeneous characteristics. All EVSE that comprise the lot shall correspond to the same type approval, and shall have the same year of manufacture.

##### 8.4.2 Samples

Samples shall be randomly taken from a lot.

##### 8.4.3 Statistical testing

The statistical control shall be based on attributes. The sampling system shall ensure:

- An Acceptance Quality Level (AQL) of not more than 1%; and
- A Limiting Quality (LQ) of not more than 7%.

The AQL is the maximum percentage of non-conforming items in a lot at which the lot has a probability of 95% to be accepted.

The LQ is the percentage of non-conforming items in a lot at which the lot has a maximum probability of 5% to be accepted.

Note: These requirements allow for substantial freedom in the verification program. Examples are given below based on a lot of 1000 EVSE.

Number of EVSE tested	40	70	100	1000
Maximum number of non-conforming EVSE.	0	1	2	10

#### 8.5 In situ testing

*In situ* testing may be used for either verification or re-verification if allowed by the national authority. The national authority may set lower accuracy requirements for *in situ* testing based on the lack of control over the environments conditions of the tests.

# Annex A Bibliography

(Informative)

Ref.	Standards and reference documents	Description
[1]	OIML D 11 (2013) General Requirements for electronic measuring instruments	Guidance for establishing appropriate metrological performance testing requirements for influence quantities that may affect the measuring instruments covered by International Recommendations.
[2]	OIML D 31 (2019) General Requirements for software controlled measuring instruments	Guidance for establishing appropriate requirements for software related functionalities in measuring instruments covered by OIML Recommendations.
[3]	OIML V 2-200 (2012) International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)	Vocabulary, prepared by a joint working group consisting of experts appointed by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, and OIML
[4]	OIML V1 (2013) International vocabulary of terms in legal metrology (VIML)	The VIML includes only the concepts used in the field of legal metrology. These concepts concern the activities of the legal metrology service, the relevant documents, as well as other problems linked with this activity. Also included in this Vocabulary are certain concepts of a general character which have been drawn from the VIM.
[5]	OIML G 1-100 (2008), (GUM) Evaluation of measurement data - Guide to the expression of uncertainty in measurement.	This Guide establishes general rules for evaluating and expressing uncertainty in measurement that are intended to be applicable to a broad spectrum of measurements.
[6]	OIML TC 3/SC 4, 3 <sup>rd</sup> committee draft, 13 July 2010 Surveillance of utility meters in service on the basis of sampling inspections.	This is a draft OIML document that relates to the method and procedure according to which the period of validity of the verification of utility meters forming part of a defined lot is extended if the correctness of the meters has been proved by sampling inspections prior to the expiry of the period of validity of the verification.
[7]	IEC 60060-1 ed 3.0 (2010) High-voltage Test Techniques. Part 1: General Definitions and Test Requirements.	This part of IEC 60060 is applicable to: – dielectric tests with direct voltage; – dielectric tests with alternating voltage; – dielectric tests with impulse voltage; – dielectric tests with combinations of the above.
[8]	IEC 60068-2-1 (2007) Environmental testing. Part 2: Tests. Test A: Cold.	This part of IEC 60068 deals with cold tests applicable to both non heat-dissipating and heat-dissipating specimens. The object of the cold test is limited to the determination of the ability of components, equipment or other articles to be used, transported or stored at low temperature. Cold tests covered by this Standard do not enable the ability of specimens to withstand or operate during the temperature variations to be assessed. In this case, it would be necessary to use IEC 60068-2-14.
[9]	IEC 60068-2-2 (2007) Environmental testing. Part 2: Tests. Test B: Dry heat.	This part of IEC 60068 deals with dry heat tests applicable both to heat-dissipating and non heat-dissipating specimens. The object of the dry heat test is limited to the determination of the ability of components, equipment or other articles to be used, transported or stored at high temperature. These dry heat tests do not enable the ability of specimens to withstand or operate during the temperature variations to be assessed. In this case, it would be necessary to use IEC 60068-2-14 Test N: Change of temperature.
[10]	IEC 60068-2-18 (2000) Environmental testing. Part 2- Test R and guidance: Water.	Provides methods of test applicable to products which, during transportation, storage or in service, may be subjected to falling drops, impacting water or immersion. The primary purpose of water tests is to verify the ability of enclosures, covers and seals to maintain components and equipment in good working order after and, when necessary, under a standardized dropfield or immersion in water.
[11]	IEC 60068-2-27 Ed. 4.0 (2008) Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock	Provides a standard procedure for determining the ability of a specimen to withstand specified severities of non-repetitive or repetitive shocks. The purpose of this test is to reveal mechanical weakness and/or degradation in specified performances, or accumulated damage or degradation caused by shocks.
[12]	IEC 60068-2-30 (2005) Environmental testing. Part 2-30: Tests. Test Db: Damp heat, cyclic (12+12-hour cycle).	Determines the suitability of components, equipment and other articles for use and/or storage under conditions of high humidity when combined with cyclic temperature changes.

[13]	IEC 60068-2-47 (2005) Environmental testing - Part 2-47: Test - Mounting of specimens for vibration, impact and similar dynamic tests.	Provides methods of mounting components, and mounting requirements for equipment and other articles, for the families of dynamic tests in IEC 60068-2, that is impact (Test E), vibration (Test F) and acceleration, steady-state (Test G).
[14]	IEC 60068-2-64 (2008) Environmental testing - Part 2: Test methods - Test Fh: Vibration, broad-band random (digital control) and guidance.	Determines the ability to withstand specified severities of broad-band random vibration. Applies to specimens which may be subjected to vibration of a stochastic nature by transportation or operational environments, for example in aircraft, space vehicles and land vehicles. Has the status of a basic safety publication in accordance with IEC Guide 104.
[15]	IEC 60068-2-78 (2001) Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state.	Provides a test method for determining the suitability of electrotechnical products, components or equipment for transportation, storage and use under conditions of high humidity. The test is primarily intended to permit the observation of the effect of high humidity at constant temperature without condensation on the specimen over a prescribed period.
[16]	IEC 60068-3-1 Ed 2.0 (2011-08) Environmental testing - Part 3-1: Supporting documentation and guidance - Cold and dry heat tests	Gives background information for Tests A: Cold (IEC 68-2-1), and Tests B: Dry heat (IEC 68-2-2). Includes appendices on the effect of: chamber size on the surface temperature of a specimen when no forced air circulation is used; airflow on chamber conditions; on surface temperatures of test specimens; wire termination dimensions and material on surface temperature of a component; measurements of temperature, air velocity and emission coefficient.
[17]	IEC 60068-3-4 (2001) Environmental testing. Part 3-4- Supporting documentation and guidance - Damp heat tests.	Provides the necessary information to assist in preparing relevant specifications, such as standards for components or equipment, in order to select appropriate tests and test severities for specific products and, in some cases, specific types of application. The object of damp heat tests is to determine the ability of products to withstand the stresses occurring in a high relative humidity environment, with or without condensation, and with special regard to variations of electrical and mechanical characteristics. Damp heat tests may also be utilized to check the resistance of a specimen to some forms of corrosion attack.
[18]	IEC 60512-14-7 (1997) Electromechanical components for electronic equipment - Basic testing procedures and measuring methods - Part 14: Sealing tests - Section 7: Test 14g: Impacting water.	Defines a standard test method to assess the effects of impacting water or specified fluid on electrical connecting devices.
[19]	IEC 60529 (2001), Corrigendum IEC 60529-cor1 (2003), IEC 60529-cor2 (2007) and IEC 60529 Corr.3 (2009-10) Degrees of protection provided by enclosures (IP Code).	Applies to the classification of degrees of protection provided by enclosures for electrical equipment with a rated voltage not exceeding 72.5 kV. Has the status of a basic safety publication in accordance with IEC Guide 104.
[20]	IEC 61000-4-1 (2006) Electromagnetic compatibility (EMC) - Part 4-1: Testing and measurement techniques - Overview of IEC 61000-4 series.	Gives applicability assistance to the users and manufacturers of electrical and electronic equipment on EMC standards within the IEC 61000-4 series on testing and measurement techniques. Provides general recommendations concerning the choice of relevant tests.
[21]	IEC 61000-4-2 (2008) Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test.	Relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, from operators directly, and to adjacent objects. Additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures. The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. In addition, it includes electrostatic discharges which may occur from personnel to objects near vital equipment.
[22]	IEC 61000-4-3 (2010). Electromagnetic compatibility (EMC). Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test.	Applies to the immunity of electrical and electronic equipment to radiated electromagnetic energy. Establishes test levels and the required test procedures. Establishes a common reference for evaluating the performance of electrical and electronic equipment when subjected to radio-frequency electromagnetic fields.
[23]	IEC 61000-4-4 (2012) Electromagnetic compatibility (EMC). Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity tests.	Establishes a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to electrical fast transient/burst on supply, signal, control and earth ports. The test method documented in this part of IEC 61000-4 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.
[24]	IEC 61000-4-5 (2005), corr. 1 (2009-10) Electromagnetic compatibility (EMC). Part 4-5: Testing and measurement techniques - Surge immunity test.	Relates to the immunity requirements, test methods, and range of recommended test levels for equipment to unidirectional surges caused by overvoltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions. These requirements are developed for and are applicable to electrical and electronic equipment. Establishes a common reference for evaluating the performance of equipment when subjected to high-energy disturbances on the power and inter-connection lines.
[25]	IEC 61000-4-6 (2008)	Relates to the conducted immunity requirements of electrical and electronic equipment to electromagnetic disturbances coming from intended radio-frequency (RF) transmitters in the frequency range 9 kHz - 80 MHz. Equipment not having at least one conducting cable

	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields.	(such as mains supply, signal line or earth connection), which can couple the equipment to the disturbing RF fields is excluded.
[26]	IEC 61000-4-8, Ed. 2.0 (2009-09) Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test.	Relates to the immunity requirements of equipment, only under operational conditions, to magnetic disturbances at power frequency related to: – residential and commercial locations; – industrial installations and power plants; and – medium voltage and high voltage sub-stations.
[27]	IEC 61000-4-11 (2004) Electromagnetic compatibility (EMC). Part 4-11: Testing and measurement techniques -: Voltage dips, short interruptions and voltage variation immunity tests.	Defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations. This standard applies to electrical and electronic equipment having a rated input current not exceeding 16 A per phase, for connection to 50 Hz or 60 Hz a.c. networks.
[28]	IEC 61000-4-12 (2006) Electromagnetic compatibility (EMC) - Part 4-12: Testing and measurement techniques - Ring wave immunity test.	Relates to the immunity requirements and test methods for electrical and electronic equipment, under operational conditions, to non-repetitive damped oscillatory transients (ring waves) occurring in low-voltage power, control and signal lines supplied by public and non-public networks.
[29]	IEC 61000-6-1(2005) Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments.	Defines the immunity test requirements in relation to continuous and transient, conducted and radiated disturbances, including electrostatic discharges, for electrical and electronic apparatus intended for use in residential, commercial and light-industrial environment, and for which no dedicated product or product-family standard exists. Immunity requirements in the frequency range 0 kHz - 400 GHz are covered and are specified for each port considered. This standard applies to apparatus intended to be directly connected to a low-voltage public mains network or connected to a dedicated DC source which is intended to interface between the apparatus and the low-voltage public mains network.
[30]	IEC 61000-6-2 (2005) Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments.	Applies to electrical and electronic apparatus intended for use in industrial environments, for which no dedicated product or product-family immunity standard exists. Immunity requirements in the frequency range 0 Hz - 400 GHz are covered, in relation to continuous and transient, conducted and radiated disturbances, including electrostatic discharges. Test requirements are specified for each port considered.  Apparatus intended to be used in industrial locations are characterized by the existence of one or more of the following: - a power network powered by a high or medium voltage power transformer dedicated to the supply of an installation feeding manufacturing or similar plant; - industrial, scientific and medical (ISM) apparatus; - heavy inductive or capacitive loads that are frequently switched; - currents and associated magnetic fields that are high.
[31]	IEC 62052-11 (2003) Electricity metering equipment (AC) - General requirements, tests and test conditions - Part 11: Metering equipment.	Covers type tests for electricity metering equipment for indoor and outdoor application and to newly manufactured equipment designed to measure the electric energy on 50 Hz or 60 Hz networks, with a voltage up to 600 V. It applies to electromechanical or static meters for indoor and outdoor application consisting of a measuring element and register(s) enclosed together in a meter case. It also applies to operation indicator(s) and test output(s)
[32]	IEC 62053-52 (2005) Electricity metering equipment (AC) - Particular requirements - Part 52: Symbols.	Applies to letter and graphical symbols intended for marking on and identifying the function of electromechanical or static a.c. electricity meters and their auxiliary devices. The symbols specified in this standard shall be marked on the name-plate, dial plate, external labels or accessories, or shown on the display of the meter as appropriate.
[33]	ISO 4892-3 Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps	Specifies methods for exposing specimens to fluorescent UV radiation and water in apparatus to designed reproduce the weathering effects that occur when materials are exposed in actual end-use environments to daylight, or to daylight through window glass.

## Annex B Estimation of combined errors

(Informative)

### Estimate of combined maximum permissible error based on the requirements of this Recommendation

This Recommendation permits a base maximum permissible error plus an error shift caused by influence quantities. The actual error of a complying EVSE when in use could therefore exceed the base maximum permissible error. There is a need to estimate an overall maximum permissible error that indicates the largest error that can reasonably be attributed to a EVSE type that complies with this Recommendation. This entails estimating the errors of a measurement of an arbitrary EVSE within the rated operating conditions.

However, adding the base maximum permissible error and all error shifts algebraically would give a much too pessimistic estimate of the metering uncertainty, for two reasons. For an arbitrary set of influence factor values, some of the error shifts will be low and some will probably have opposite signs, tending to cancel each other out. Furthermore, the electricity EVSE is an integrating device, thus the errors caused by influence quantities will average out to some extent as the values of the influence factors vary over time.

If we make the following assumptions:

- a) The integrating effect may be ignored,
- b) None of the effects of the influence factors are correlated,
- c) The values of the influence quantities are more likely to be close to the reference values than to limits of the rated operated conditions,
- d) The influence quantities, and the effects of the influence factors, can be treated as Gaussian distributions, and thus a value of half the maximum permissible error shift can be used for the standard uncertainty,

Then the combined maximum permissible error (assuming a coverage factor of two corresponding to a coverage probability of approximately 95 %) can be estimated using the formula<sup>(1)</sup>:

$$v = 2 * \sqrt{\frac{v_{base}^2}{4} + \frac{v_{voltage}^2}{4} + \frac{v_{frequency}^2}{4} + \frac{v_{unbalance}^2}{4} + \frac{v_{harmonic}^2}{4} + \frac{v_{temperature}^2}{4}}$$

where:

$v_{base}$  is the base maximum permissible error;

$v_{voltage}$  is the maximum error shift permitted for voltage variation;

$v_{frequency}$  is the maximum error shift permitted for frequency variation;

$v_{unbalance}$  is the maximum error shift permitted for unbalance variation;

$v_{harmonics}$  is the maximum error shift permitted for the variation of harmonic content;

$v_{temperature}$  is the maximum error shift permitted for temperature variation.

Note (1): This is line with the ISO Guide to the expression of uncertainty of measurement (GUM).

# Estimation of combined error based on type test results and specific conditions

## Method 1

The combined maximum error can also be estimated for a particular EVSE type using type test results. Type test results can often show a smaller variation than that required by this Recommendation, leading to an assured smaller value for the overall maximum error.

Keeping the assumption of a Gaussian distribution being valid the combined maximum error can then be estimated from a combination of test results using the formula <sup>(3)</sup>:

$$e_{c(p,i)} = \sqrt{(e^2(PF_p, I_i) + \delta e_{p,i}^2(T) + \delta e_{p,i}^2(U) + \delta e_{p,i}^2(f))}$$

where:

For each current  $I_i$  and each power factor  $PF_p$

$e(PF_p, I_i)$  is the intrinsic error of the EVSE measured in the course of the tests, at current  $I_i$  and power factor  $PF_p$ ;

$\delta e_{p,i}(T)$ ,  $\delta e_{p,i}(U)$ ,  $\delta e_{p,i}(f)$  are the maximum additional errors measured in the course the test, when the temperature, the voltage and the frequency are respectively varied over the whole range specified in the rated operated conditions, at current  $I_i$  and power factor  $PF_p$

## Method 2

When assuming that a Gaussian distribution may no longer be valid, instead a rectangular distribution should be assumed for the effects of influence factors.

Thus, the combined maximum error can then be estimated from a combination of test results using the formula <sup>(3)</sup>:

$$e_c = 2 \times \sqrt{\frac{e_{\text{base}}^2}{3} + \frac{e_{\text{voltage}}^2}{3} + \frac{e_{\text{frequency}}^2}{3} + \frac{e_{\text{unbalance}}^2}{3} + \frac{e_{\text{harmonic}}^2}{3} + \frac{e_{\text{temperature}}^2}{3}}$$

where:

$e_{\text{base}}$  is the maximum error obtained in the test for base maximum error, taking into account the measurement uncertainty of the type test<sup>(2)</sup>;

$e_{\text{voltage}}$  is the maximum error shift obtained in the test for voltage variation, taking into account the measurement uncertainty of the type test;

$e_{\text{frequency}}$  is the maximum error shift obtained in the test for frequency variation, taking into account the measurement uncertainty of the type test;

$e_{\text{unbalance}}$  is the maximum error shift obtained in the test for unbalance variation, taking into account the measurement uncertainty of the type test;

$e_{\text{harmonics}}$  is the maximum error shift obtained in the test for variation of harmonic content, taking into account the measurement uncertainty of the type test;

$e_{\text{temperature}}$  is the maximum error shift obtained in the test for temperature variation, taking into account the measurement uncertainty of the type test.

Note (2): The measurement uncertainty must be included in each component  $e_i$  of the overall error. Since one term is a known value and the other an uncertainty they cannot be treated as two uncorrelated statistical distributions, and must hence be added algebraically.

Note (3): Components contributing to the combined error may be selected by national or regional authorities and should at least comprise:  $e_{\text{base}}$ ,  $e_{\text{frequency}}$ ,  $e_{\text{temperature}}$  and  $e_{\text{voltage}}$ .

The effects of correlations between factors such as load profiles and ambient temperature variation on EVSE accuracy have not been included in the above calculations, but could be modeled in situations where appropriate.

