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BSI Standards Publication

Electrically propelled road vehicles — Magnetic field wireless power transfer — Safety and interoperability requirements

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National foreword

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

ISO PAS 19363:2017 was prepared by Technical Committee ISO/TC 22, *Road vehicles,* SC 37, *Electrically propelled vehicles*, in collaboration with IEC/TC 69 *Electric road vehicles and electric industrial trucks,* in accordance with ISO/IEC mode of cooperation 4.

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Introduction

This document is an intermediate specification, published prior to the development of a full International Standard. This document prescribes the usage of the wireless power transfer technology to charge electrically propelled road vehicles. Even if the technology itself is well known, the implementation in a vehicle is new and demands to meet the very specific requirements of the automotive industry. The main purpose of this document is to respond to the upcoming market needs starting with determination of basic safety requirements and documentation for the first findings for vehicle usage.

This document will be transformed into an International Standard as soon as consolidated technical experiences are available. When transferring this document into an IS, technical changes are possible to adopt the document to the latest level of knowledge.

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Electrically propelled road vehicles — Magnetic field wireless power transfer — Safety and interoperability requirements

1 Scope

This document defines the requirements and operation of the on-board vehicle equipment that enables magnetic field wireless power transfer (MF-WPT) for traction battery charging of electric vehicles. It is intended to be used for passenger cars and light duty vehicles.

This document addresses the following aspects for an EV device:

— transferred power;

— ground clearance;

— interoperability requirements among differently classified EV devices and associated off-vehicle systems;

— performance requirements under various conditions, including among different manufacturers and classifications;

— safety requirements;

— test procedures.

EV devices according to this document are intended to operate with off-board systems currently under development in the IEC 61980 series.

NOTE 1 This edition covers stationary applications.

NOTE 2 Bidirectional power transfer is not considered in this edition.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6469-3, *Electrically propelled road vehicles — Safety specifications — Part 3: Protection of persons against electric shock*

ISO 14117, *Active implantable medical devices — Electromagnetic compatibility — EMC test protocols for implantable cardiac pacemakers, implantable cardioverter defibrillators and cardiac resynchronization devices*

ISO 15118-8, *Road vehicles — Vehicle to grid communication interface — Part 8: Physical layer and data link layer requirements for wireless communication*

ISO 16750-3, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 3: Mechanical loads*

ISO 16750-4, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads*

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ISO 16750-5, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 5: Chemical loads*

IEC 61786-1, *Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings - Part 1: Requirements for measuring instruments*

ICNIRP 2010, *Guidelines for limiting exposure to time varying electric and magnetic fields (1 HZ – 100 kHZ)*

ICNIRP 1998, *Guidelines for limiting exposure to time varying electric and magnetic fields (up to 300 kHZ)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
alignment
relative position of primary to *secondary device* (3.27)

3.2
alignment check
confirmation that the primary and *secondary devices* (3.27) are properly positioned relative to each other

Note 1 to entry: Proper positioning is done to assure sufficient system functionality [e.g. *system efficiency* (3.35), EMF/EMC limits, safety requirements, etc.].

3.3
basic insulation
insulation of hazardous-live-parts which provides basic protection

3.4
battery system
(battery) energy storage device that includes cells or cell assemblies or battery pack(s), as well as electrical circuits and electronics

EXAMPLE BCU, contactors.

3.5
double insulation
insulation comprising both *basic insulation* (3.3) and *supplementary insulation* (3.30)

3.6
electric shock
physiological effect resulting from an electric current through a human body

3.7
electric vehicle/electric road vehicle
EV
any vehicle propelled by an electric motor drawing current from a *battery system* (3.4) intended primarily for use on public roads

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3.8
EV communication controller
EVCC
embedded system, within the vehicle, that implements the communication between the vehicle and the SECC in order to support specific functions

Note 1 to entry: Such specific functions could be, for example, controlling input and output channels, encryption, or data transfer between vehicle and SECC.

3.9
EV device
on-board component assembly, comprising the *secondary device* (3.27), the *EV power electronics* (3.12) and the *EV communication controller* (3.8), as well as the mechanical connections between the components necessary for wireless power transfer

3.10
EV power circuit
EVPC
electrical component assembly that includes the *secondary device* (3.27) and *EV power electronics* (3.12), as well as the mechanical connections between the components

Note 1 to entry: EVPC is here defined specifically for *MF-WPT systems* (3.19).

3.11
EVPC power class
power class of an EVPC defined according to the *MF-WPT input power class* (3.18) of the supply device it is designed to operate

Note 1 to entry: The power delivered to the *EV device* (3.9) will be less than that maximum MF-WPT input power to the *MF-WPT system* (3.19) due to losses, for example, in the *supply power electronics* (3.34) and eddy currents in the MF-WPT shield or the vehicle underbody.

3.12
EV power electronics
on-board electronics, including all housings and covers, that convert the AC power from the *secondary device* (3.27) to DC power having suitable voltages and currents provided to the *battery system* (3.4) or the traction-battery

EXAMPLE Impedance matching network (IMN), filter, rectifier, impedance converter.

3.13
fine positioning
relative movement of the *secondary device* (3.27) in relation to the *primary device* (3.23) with the goal of reaching *optimal alignment* (3.20)

3.14
foreign object
object that is not an attached part of the vehicle or the *MF-WPT system* (3.19)

3.15
grid
electric power source that is not part of the vehicle for supplying electric energy to an EV using a *supply power circuit* (3.33)

3.16
Magnetic Field Wireless Power Transfer
MF-WPT
wireless transfer of energy from a power source to an electrical load via a magnetic field

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3.17
message
data in a specified format

EXAMPLE A message contains data in a specified format that describes for example, a request or a reply.

Note 1 to entry: A message contains zero or more parameters.

3.18
MF-WPT input power class
power class of a supply device of *MF-WPT systems* (3.19) defined from the perspective of the maximum power drawn from the *grid* (3.15) in order to drive the supply device

Note 1 to entry: IEC 61980-3 will specify the MF-WPT input power classes, current status of discussions: for MF-WPT1 the maximum input power is ≤3,7 kW, for MF-WPT2 the maximum input power is >3,7 kW and ≤7,7 kW, for MF-WPT3 the maximum input power is >7,7 kW and ≤11 kW, for MF-WPT4 the maximum input power is >11 kW and ≤22 kW, for MF-WPT5 the maximum input power is >22 kW. For this document, MF-WPT1 to MF-WPT4 are under consideration.

3.19
MF-WPT system
system consisting of *primary device* (3.23), *supply power electronics* (3.34), *supply equipment communication controller* (3.32), (the supply device), *secondary device* (3.27), *EV power electronics* (3.12) and electric vehicle communication controller [the *EV device* (3.9)], including wiring, housing and covers used to transfer energy using magnetic fields

Note 1 to entry: See also Figure 1.

3.20
optimal alignment
alignment (3.1) with the most efficient power transfer

3.21
pairing
process by which an EV is correlated with the unique dedicated *primary device* (3.23) at which it is located and from which power will be transferred

3.22
power saver mode
mode in which the EV either turns *EV device* (3.9) components off or into a mode with reduced power consumption

3.23
primary device
device external to the EV that is the source of the MF-WPT, including all housings and covers

Note 1 to entry: When the EV is receiving power, the primary device acts as the source of the power to be transferred.

3.24
protection area
volume in and around the vehicle that has homogeneous protection target requirements

3.25
reference level
levels of field strength or power density derived from the basic restrictions using worst case assumptions about exposure

Note 1 to entry: If the reference levels are met, then the basic restrictions will be complied with, but if the reference levels are exceeded, that does not necessarily mean that the basic restriction will not be met.

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3.26
reinforced insulation
insulation of hazardous live parts which provides a degree of protection against *electric shock* (3.6) equivalent to *double insulation* (3.5)

Note 1 to entry: Reinforced insulation may comprise several layers which cannot be tested singly as *basic insulation* (3.3) or *supplementary insulation* (3.30).

3.27
secondary device
device mounted on the EV, including all housings and covers, that captures the magnetic field sourced by the *primary device* (3.23)

Note 1 to entry: When the EV is receiving power, the *secondary device* (3.28) transfers the power from the primary to the EV.

3.28
secondary device ground clearance
vertical distance between the ground surface and the lowest point of the *secondary device* (3.28)

Note 1 to entry: The lower surface may not be planar and may not be parallel to the ground surface.

3.29
steady state
state of a system at which all state and output variables remain constant in time while all input variables are constant

3.30
supplementary insulation
independent insulation applied in addition to *basic insulation* (3.3) for fault protection

3.31
supply device
off-board component assembly comprising the *primary device* (3.23), the *supply power electronics* (3.34) and the supply device communication controller, as well as the mechanical connections between the components necessary for wireless power transfer

3.32
supply equipment communication controller
SECC
entity which implements the communication to one or multiple *EVCCs* (3.8)

Note 1 to entry: Functions of an SECC control input and output channels, data encryption, or data transfer between vehicle and SECC.

3.33
supply power circuit
off-board component assembly comprising the *supply power electronics* (3.34) and *primary device* (3.23), as well as the mechanical connections between the components

3.34
supply power electronics
off-board electronics, including all housings and covers, that supply the electric power to the *primary device* (3.23)

EXAMPLE PFC converter, DC-AC inverter, filter, impedance matching network.

3.35
system efficiency
efficiency from AC or DC power supply (input of the supply device) to the output of the *EV device* (3.9)

Note 1 to entry: It is of no importance whether the output is connected to a device or directly to a battery.

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3.36
voltage class B
classification of an electric component or circuit with a maximum working voltage of >30 V and ≤1,000 V AC (rms) or >60 V DC and ≤1,500 V DC, respectively

4 Environmental conditions

Potential environmental stresses and related tests and requirements for electronic systems/components mounted in specific locations on/in the vehicle are described in ISO 16750.

The environmental requirements applicable to a particular EV device shall be identified and agreed between the customer and supplier and the compliance testing for these requirements shall be performed in accordance with the following ISO standards:

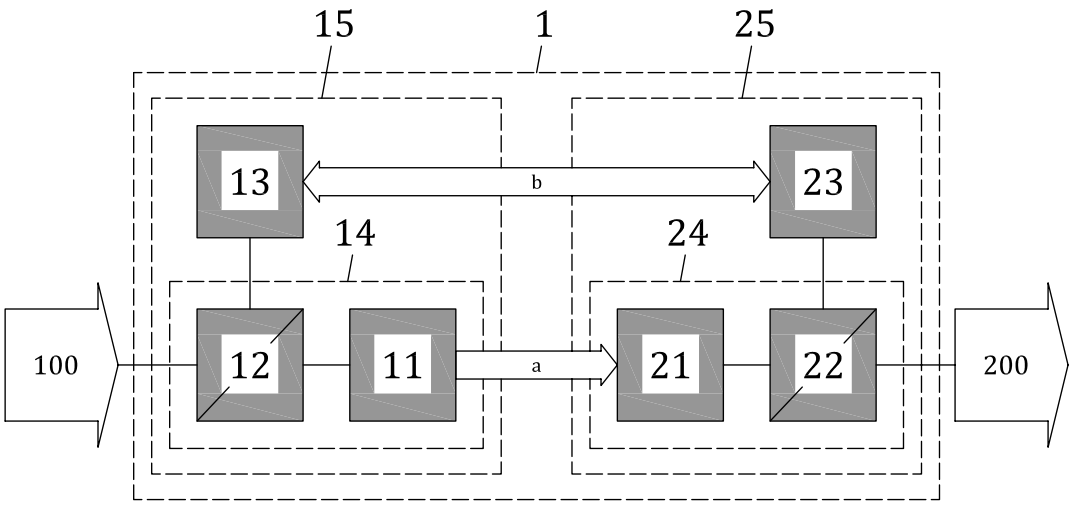
— mechanical loads according to ISO 16750-3, test procedure type VI, vehicle body;

— climate loads according to ISO 16750-4;

— chemical loads according to ISO 16750-5.

5 System description

Figure 1 shows an example for the structure of an MF-WPT system.



Key

1 MF-WPT system
11 primary device
12 supply power electronics
13 supply equipment communication controller (SECC)
14 supply power circuit
15 supply device
100 grid
21 secondary device
22 EV power electronics
23 EV communication controller (EVCC)
24 EV power circuit (EVPC)
25 EV device
200 battery
a Wireless power flow.
b Communication.

NOTE The numbering convention adopted is based on system blocks being assigned a number with the supply device blocks having numbers of the form "1X" and the EV device blocks of the form "2X". The second digit identifies equivalent functionality in the supply and EV sub-systems.

Figure 1 — MF-WPT system

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6 MF-WPT interoperability

6.1 General

Interoperability refers to the capability of the supply device and the EV device being able to transfer power wirelessly in a safe and efficient manner, based on compliance with the requirements in this document.

In order to determine interoperability, an EV device shall be tested according to 6.6 with the reference supply devices for which it is designed to operate.

NOTE 1 IEC 61980-3 will specify the reference supply devices. A supply device is designed so that it is operable with the relevant reference EV devices, specified in this document. In order to determine interoperability, a supply device is tested with the relevant reference EV devices specified in this document. This allows EV devices and supply devices to be sourced independently.

NOTE 2 The interoperability of the functions and communication is specified in Clause 7 and Clause 8.

6.2 Classification of EV power circuits

6.2.1 General

The reference EV devices are classified by MF-WPT class and Z class.

NOTE For this document, it is assumed that supply devices are designed to serve all Z classes.

6.2.2 MF-WPT classes

An EVPC shall be classified for one or more MF-WPT classes.

The maximum power of an EVPC shall be specified.

A reference EV device is classified for one MF-WPT class.

Reference EV devices are verified to meet the performance requirements (see 6.3) up to the maximum power of the MF-WPT class it is assigned to.

MF-WPT class interoperability requirements between the supply device and an EVPC are shown in Table 1.

Table 1 — MF-WPT Class Interoperability Requirements

		Supply device MF-WPT input power class			
		MF-WPT1	MF-WPT2	MF-WPT3	MF-WPT4
EVPC MF-WPT class	MF-WPT1	Required	Required[a]	a	a
	MF-WPT2	Required[a]	Required	a	a
	MF-WPT3	a	a	Required	a
	MF-WPT4	a	a	a	Required

[a] Under consideration.

MF-WPT class interoperability implies that the EV device shall be able to request adaptation of output power of the supply device.

6.2.3 Z classes

The Z classes as specified in Table 2 are based on the secondary device ground clearance.

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Table 2 — Z classes

Z class	Secondary device ground clearance mm
Z1	100 to 150
Z2	140 to 210
Z3	170 to 250
NOTE Alternative for Z3 as 200 mm to 250 mm is under discussion.	

A reference EV device is verified to meet the performance requirements (see 6.3) within the entire Z class for which it is specified.

The secondary device ground clearance range for which an EVPC is designed shall be specified.

An EVPC shall meet the performance requirements (see 6.3) within the secondary device ground clearance range for which it is specified when tested with the reference supply device(s).

6.3 Performance requirements

6.3.1 General

An EVPC shall meet the performance requirements within the secondary device ground clearance range and within the power range as specified by the manufacturer when tested with the corresponding reference supply device.

6.3.2 Alignment tolerance requirements

The reference EV device are verified to meet the power transfer requirements as in 6.3.3 and the system efficiency requirements as in 6.3.4 over its entire Z class and the alignment tolerances in x and y direction (see Table 4).

An EVPC shall meet the requirements as in 6.3.3 and 6.3.4 over its entire secondary device ground clearance range and the alignment tolerances in x and y direction (see Table 3).

NOTE 1 Compliance is verified by including the maximum misalignment point within the test plan. The test conditions are defined in the test procedure.

NOTE 2 The alignment tolerances are defined with respect to the optimal alignment.

Table 3 — x and y alignment tolerance requirements

Axis	Alignment tolerance (mm)
x	±75
y	±100

The EV may have the capability to assist the driver in aligning the vehicle for proper coupling between the primary and secondary device. This functionality may require some support from the supply power circuit and standardization of this mechanism may be desired. The definition of such a mechanism does not preclude the use of alternate mechanisms by the EV.

6.3.3 Power transfer requirements

A reference EV device shall deliver the requested power under steady-state condition up to maximum power of the MF-WPT class for which it is specified.

An EVPC shall deliver the requested power under steady-state condition up to the power for which it is specified by the vehicle manufacturer.

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A requested change in power delivery shall not cause a DC output voltage overshoot of an EVPC by more than ±250 V/ms with the peak voltage not higher than 10 % of the nominal DC output voltage. The DC output voltage ripple amplitude of an EVPC shall not exceed ±8 V.

6.3.4 System efficiency requirements

The minimum system efficiency shall be according to Table 4.

Table 4 — Minimum efficiency

Alignment	Minimum system efficiency
Optimal alignment	85 %
Within alignment tolerance	80 %

If auxiliary loads (e.g. thermal management or foreign object detection) are mandatory for a system specific application (e.g. higher power classes or higher flux), their power consumption shall also be included in the system efficiency calculation.

If auxiliary loads are not mandatory and partial load is not applicable for a system specific application, this shall be confirmed in a clear statement as part of the measurement procedure and type certification documents.

6.4 Frequency

To ensure interoperability, the power transfer shall be operated within the system frequency range respectively at the nominal frequency, according to Table 5.

Table 5 — Frequency

Description	**Frequency** (kHz)
System frequency range	81,38 to 90,00
Nominal frequency	85 ± 0,1

A fixed-frequency system shall transfer the power at the nominal frequency.

For frequency-tuneable systems, the nominal frequency is typically observed under optimal alignment and while the system is in a steady-state. Frequency-tuneable systems may transfer power at any frequency within the system frequency range.

NOTE To optimize the system efficiency, the MF-WPT system (or the supply power circuit) can tune the frequency within the system frequency range.

6.5 Reference EV devices

Reference EV devices for MF-WPT1 and MF-WPT2 are described in Annex A to Annex D.

NOTE Annex A to Annex D reflect the state-of-the-art proposals for reference EV devices that are under discussion. Technical investigations are ongoing to specify the reference EV devices and interoperability requirements.

6.6 Test procedure

Power transfer and system efficiency requirements shall be tested with the following setup:

— the EV device is connected to a battery or a simulated DC load.

Power transfer and system efficiency requirements shall be tested under the following conditions:

— ambient temperature of 25 °C ± 5 °C;

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— the system is in steady-state;

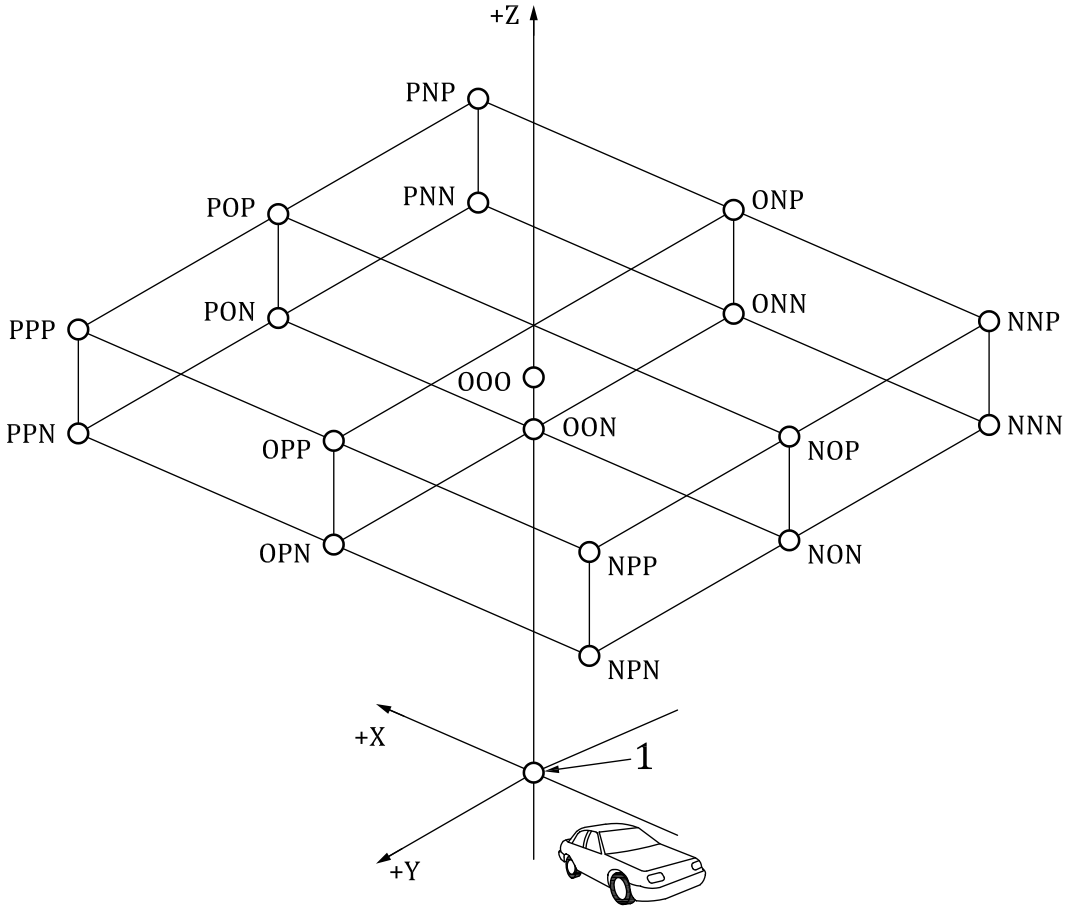
— output voltage of the EV device of 280 V, 350 V and 420 V;

— maximum output power of the EV device. The maximum output power of the EV device is specified by the manufacturer.

NOTE 1 According to Figure 1, "output power of the EV device" means the power which the EV device is able to provide to the battery.

NOTE 2 Other output voltage can be selected in the future application.

Power transfer and system efficiency requirements shall be tested in the positions as specified in Figure 2.



Key

1 optimal alignment

NOTE The coordinate system complies with ISO 4130.

Figure 2 — Measurement positions

The values of the measurement position in Figure 2 are given in Table 6.

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Table 6 — Measurement positions

Point X Y Z	Coordinate value (mm)				
	X	Y	Secondary device ground clearance (Z)		
			Z1 class	Z2 class	Z3 class
P P P	+75	+100	150	210	250
P P N			100	140	170
P 0 P		0	150	210	250
P 0 N			100	140	170
P N P		−100	150	210	250
P N N			100	140	170
0 P P	0	+100	150	210	250
0 P N			100	140	170
0 0 0		0	125	175	210
0 0 N			100	140	170
0 N P		−100	150	210	250
0 N N			100	140	170
N P P	-75	+100	150	210	250
N P N			100	140	170
N 0 P		0	150	210	250
N 0 N			100	140	170
N N P		−100	150	210	250
N N N			100	140	170

The values for the secondary device ground clearance shown in Table 6 are used for measuring reference EV devices. For testing EV devices, the maximal and minimal secondary device ground clearance shall be according to the specification by the manufacturer.

7 Functions

7.1 Communication setup

Communication setup shall be initiated by the EVCC. The EVCC shall be able to verify communication is properly established.

7.2 Service selection

7.2.1 General

The EVCC shall request available services and possible power transfer options from the SECC.

In order to be able to serve multiple EVs with different EVPC power classes or other different MF-WPT system characteristics, a supply site may be organized to offer different options for WPT at different supply power circuits which are all using one SECC in common for communication. This function will allow the EVCC and SECC to determine what fine positioning and pairing methods to use. This function may increase comfort in terms of a pre-selection of valid WPT options and optimization of guidance functionality. The SECC may provide the same information as in the final compatibility check, as well as information about the methods for fine positioning, pairing and initial alignment check. The situation of a home garage with a SECC serving only one primary device maybe treated as a special case of the situation sketched above.

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7.2.2 Parameters to be exchanged for interoperability

The EVCC shall send the following parameters for service selection:

— EVPC power class;

— maximum receivable power;

— maximum secondary device ground clearance;

— minimum secondary device ground clearance;

— minimum operating frequency;

— maximum operating frequency;

— type of geometry of the secondary device;

— circuit topology;

— fine positioning methods;

— pairing methods;

— initial alignment check methods;

— manufacturer ID;

— manufacturer specific data container;

— specific Service Provider (optional).

NOTE The EVCC expects corresponding information from the SECC according to IEC 61980–2 (under development).

7.3 Fine positioning

Fine positioning begins when the EV is entering the chosen WPT spot and guidance is provided to the driver. The goal is to reach an alignment within the alignment tolerance requirements (see 6.3.2). The method for fine positioning shall be chosen during service selection.

7.4 Pairing

The EV shall initiate the pairing process by sending a pairing request to the SECC.

The method for pairing is chosen during service selection. The EVCC shall be able to confirm pairing.

7.5 Final compatibility check

The compatibility of the primary and the secondary device shall be checked after pairing and prior to power transfer.

The EVCC shall confirm compatibility with the SECC.

7.6 Initial alignment check

The EV shall request the initial alignment check to be performed by the supply device using the method that was chosen during service selection.

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The initial alignment check ensures that alignment is within the alignment tolerance requirements (see 6.3.2) before the power transfer starts.

NOTE The function is performed by the supply device according to IEC 61980-2 (under development).

7.7 Start power transfer

Power transfer shall be initiated by request of the EV.

The EV shall request power transfer only when safety monitoring and diagnostic functions according to 7.12 are active.

7.8 Power saver mode

7.8.1 Start power saver mode

To start power saver mode, the EVCC shall inform the SECC that power saver mode will be turned on, and provides the duration for the power saver mode.

In case the SECC agrees, then the EV may go into power saver mode.

SECC and EVCC may negotiate an extension to the power saver mode.

7.8.2 Terminate power saver mode

Once the negotiated time has expired, the EV terminates power saver mode.

The EV may terminate power saver mode at any time.

NOTE Further actions after termination of power saver mode are under consideration.

7.9 Perform power transfer

Transfer of the power from the primary device to the secondary device shall be in accordance with the power request of the vehicle. The EV shall be able to request a specific amount of power, with the power to be specified in watts.

The EV shall not request more power than the supply device has indicated being able to transfer.

If the EV needs less power than the lower limit of the supply device, the EV shall request zero power.

The EV may also be able to request zero power in order to pause power transfer.

NOTE 1 The maximum power the supply device is able to deliver can change during the power transfer process.

NOTE 2 If the supply device is not able to deliver the amount of power which is requested by the EV, the supply device will indicate that it is unable to service the request and will continue to transfer power at the same rate.

NOTE 3 Timing of exchange of power transfer parameters between supply device and EV device under development.

7.10 Stop power transfer

When the EV wants to terminate power transfer, the EVCC shall send a message to the SECC indicating to stop power transfer.

NOTE This does not terminate communication.

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