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**Electric vehicle wireless power transfer (WPT) systems –
Part 3: Specific requirements for magnetic field wireless power transfer systems**

**Systèmes de transfert de puissance sans fil (WPT) pour véhicules électriques –
Partie 3: Exigences spécifiques pour les systèmes de transfert de puissance
sans fil par champ magnétique**



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IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Partie 3: Exigences spécifiques pour les systèmes de transfert de puissance
sans fil par champ magnétique**

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ELECTRIC VEHICLE WIRELESS POWER TRANSFER (WPT) SYSTEMS –**Part 3: Specific requirements for magnetic
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IEC 61980-3 has been prepared by IEC technical committee 69: Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
69/857/FDIS	69/866/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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A list of all parts of the IEC 61980 series, published under the general title *Electric vehicle wireless power transfer (WPT) systems*, can be found on the IEC website.

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INTRODUCTION

The IEC 61980 series is published in separate parts according to the following structure:

- IEC 61980-1 covers general requirements for electric road vehicle (EV) wireless power transfer (WPT) systems including general background and definitions (e.g. efficiency, electrical safety, EMC, EMF);
- IEC 61980-2¹ specifically applies to magnetic field wireless power transfer (MF-WPT) for electric road vehicles (EV) and covers specific requirements for system activities and communication between the electric road vehicle side and the off-board side, including general background and definitions;
- IEC 61980-3 covers specific power transfer requirements for the off-board side of magnetic field wireless power transfer systems for electric road vehicles (e.g. efficiency, electrical safety, EMC, EMF).

Requirements for the on-board side of MF-WPT for electric road vehicles are covered in ISO 19363.

IEC 61980-3 follows the structure of IEC 61980-1:2020.

¹ Under preparation. Stage at the time of publication: IEC/AFDIS 61980-2:2022.

ELECTRIC VEHICLE WIRELESS POWER TRANSFER (WPT) SYSTEMS –

Part 3: Specific requirements for magnetic field wireless power transfer systems

1 Scope

This part of IEC 61980 applies to the off-board supply equipment for wireless power transfer via magnetic field (MF-WPT) to electric road vehicles for purposes of supplying electric energy to the RESS (rechargeable energy storage system) and/or other on-board electrical systems. The MF-WPT system operates at standard supply voltage ratings per IEC 60038 up to 1 000 V AC and up to 1 500 V DC from the supply network. The power transfer takes place while the electric vehicle (EV) is stationary.

Off-board supply equipment fulfilling the requirements in this document are intended to operate with EV devices fulfilling the requirements described in ISO 19363.

The aspects covered in this document include

- the characteristics and operating conditions,
- the required level of electrical safety,
- requirements for basic communication for safety and process matters if required by a MF-WPT system,
- requirements for positioning to assure efficient and safe MF-WPT power transfer, and
- specific EMC requirements for MF-WPT systems.

The following aspects are under consideration for future documents:

- requirements for MF-WPT systems for two- and three-wheel vehicles,
- requirements for MF-WPT systems supplying power to EVs in motion,
- requirements for bidirectional power transfer,
- requirements for flush mounted primary device,
- requirements for MF-WPT systems for heavy duty vehicle, and
- requirements for MF-WPT systems with inputs greater than 11,1 kVA.

This document does not apply to

- safety aspects related to maintenance, and
- trolley buses, rail vehicles and vehicles designed primarily for use off-road.

NOTE The terms used in this document are specifically for MF-WPT.

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.

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61439-1:2020, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61439-7:2018, *Low-voltage switchgear and controlgear assemblies – Part 7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicle charging stations*

IEC 61980-1:2020, *Electric vehicle wireless power transfer (WPT) systems – Part 1: General requirements*

IEC 61980-2:—, *Electric vehicle wireless power transfer (WPT) systems – Part 2: Specific requirements for MF-WPT system communication and activities²*

ISO 19363:2020, *Electrically propelled road vehicles – Magnetic field wireless power transfer – Safety and interoperability requirements*

ISO 20653, *Road vehicles – Degrees of protection (IP code) – Protection of electrical equipment against foreign objects, water and access*

ICNIRP, *ICNIRP guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz – 100 kHz)*, Health Physics 99(6):818-836; 2010

Recommendation ITU-R SM.2110-1:2019, *Guidance on frequency ranges for operation of non-beam wireless power transmission for electric vehicles*

3 Terms and definitions

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>

Clause 3 of IEC 61980-1:2020 is applicable.

Additional terms and definitions:

3.101

accessible part

part of equipment that can be touched without the use of a tool, excluding parts when under the vehicle

3.102

alignment

relative position in X- and Y- direction of the secondary device to the primary device for a given secondary device ground clearance

3.103

alignment tolerance area

intended WPT operating area in X- and Y- direction for a given secondary device ground clearance

² Under preparation. Stage at the time of publication: IEC/AFDIS 61980-2:2022.

3.104

centre alignment point

spatial X, Y centre of the alignment tolerance area

Note 1 to entry: The centre alignment point is not a fixed point for any single coil. It only has relevance for a primary and secondary device combination and is specific for that combination.

3.105

charge session

period when the SECC is in the WPT_S_PTA or WPT_S_PT state as defined in IEC 61980-2

3.106

compatibility class A supply device

supply device that interoperates with compatibility class A EV devices

Note 1 to entry: See ISO 19363:2020, Clause 6.

Note 2 to entry: A compatibility class A supply device is interoperable with all normative reference EVPCs – see Annex A.

3.107

compatibility class B supply device

supply device that operates with at least one compatibility class B EV device and might interoperate with one or more compatibility class A EV devices

Note 1 to entry: See ISO 19363:2020, Clause 6.

Note 2 to entry: Interoperability with any of the normative reference EVPCs is optional.

3.108

connecting cable

cable which connects a physical unit containing portions of the SPC to another physical unit containing portions of the SPC

Note 1 to entry: Cables within a physical unit are not connecting cables.

3.109

DUT

device under test

3.110

electric vehicle 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 controlling input and output channels, encryption or data transfer between the vehicle and the SECC.

[SOURCE: ISO 15118-1:2019, 3.1.31]

3.111

EV power circuit

EVPC

on-board component assembly comprising the secondary device and EV power electronics as well as the mechanical connections

SEE: Figure 1.

3.112**EV power electronics**

on-board component that converts the power and frequency from the secondary device to the DC output of the EVPC

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

3.113**flush mounted**

mounting of a primary device in such a manner that the top covering of the primary device is flush with the pavement

3.114**foreign object**

object that is not an attached part of the vehicle or the WPT system

3.115**fundamental mutual inductance**

mutual inductance of two specific coils at a specific physical position relative to each other

3.116**gauge device**

test device to characterize magnetic fields associated with a coil

3.117**geometric centre**

spatial X, Y centre of the primary coil or the secondary coil

3.118**MF-WPT power class**

power class of a supply device of MF-WPT systems defined from the perspective of the maximum power drawn from the supply network in order to drive the supply device

3.119**magnetic field WPT****MF-WPT**

transfer of electrical energy from a power source to an electrical load via a magnetic field without galvanic connection

3.120**magnetic resonance**

magnetic field wireless power transfer (MF-WPT) that utilizes one or more high quality factor coils and one or more impedance matching networks or compensation networks operating at or near resonance

3.121**operating frequency**

frequency used to transmit energy between the supply device and the EV device within the system frequency range

3.122**power transfer efficiency**

ratio of the output power of the EVPC divided by the input power of the SPC

3.123**primary coil**

component of the primary device comprising one or more electrical windings and magnetic materials that generate a magnetic field for MF-WPT

3.124

primary device

off-board component comprising the primary coil and its compensation network to generate and shape the magnetic field for MF-WPT

Note 1 to entry: Includes housings, covers and cabling.

3.125

reference EVPC

EVPC that serves for conformance testing purposes

3.126

reference SPC

SPC that serves for conformance testing purposes

3.127

remaining package

assembly package or packages which contain all of the components of the supply power circuit that are not contained in the under-vehicle package

3.128

secondary coil

component of the secondary device comprising one or more electrical windings and magnetic materials that capture a magnetic field for MF-WPT

3.129

secondary device

on-board component comprising the secondary coil and its compensating network to capture the magnetic field

Note 1 to entry: Includes housings, covers and cabling.

3.130

secondary device ground clearance

vertical distance between the ground surface and the lowest point of the secondary device, including the housing

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

3.131

supply equipment communication controller

SECC

off-board component that implements the communication with the EVCC(s)

Note 1 to entry: Functions of a supply equipment communication controller may control input and output channels, data encryption or data transfer between the vehicle and the SECC.

Note 2 to entry: One SECC can control multiple supply devices for certain configurations.

3.132

supply power circuit

SPC

off-board component assembly comprising the primary device and supply power electronics, as well as the electrical and mechanical connections

SEE Figure 1.

3.133

supply power electronics

off-board component that converts the power and frequency from the supply network to the power and frequency needed by the primary device

3.134**surface mounted**

mounting of a primary device in such a manner that it protrudes above ground up to certain mounting height

3.135**system frequency range**

frequency range over which the system is designed to transfer power

3.136**under-vehicle package**

assembly package containing all of the components of the SPC which is intended to be located under the vehicle when it is in position to be charged

3.137**X**

direction of travel of the vehicle per ISO 4130

3.138**Y**

direction perpendicular to the direction of travel per ISO 4130

4 Abbreviated terms

Clause 4 of IEC 61980-1:2020 is applicable.

5 General

Clause 5 of IEC 61980-1:2020 is applicable.

6 Classification

Clause 6 of IEC 61980-1:2020 is applicable except as follows:

Addition:

6.101 Compatibility classes

The supply device is classified according to the compatibility class:

- compatibility class A supply device;
- compatibility class B supply device.

6.102 Transfer power classes

SPCs which are part of compatibility class A supply devices are classified according to MF-WPT classes as described in Table 101.

The manufacturer shall specify the rated input power of the supply power circuit.

Table 101 – MF-WPT power classes

MF-WPT class	Rated input kVA of SPC
MF-WPT1	$\leq 3,7$
MF-WPT2	$> 3,7$ and $\leq 7,7$
MF-WPT3	$> 7,7$ and $\leq 11,1$
MF-WPT4	$> 11,1$ and $\leq 22,2$

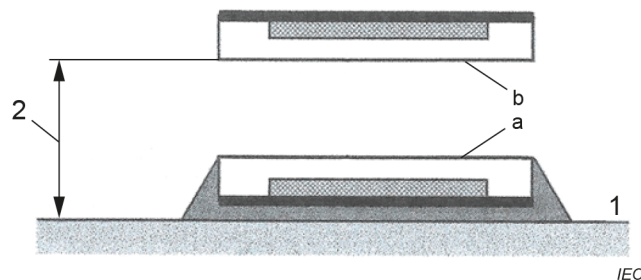
NOTE 101 Rated input power can be chosen at any value up to the maximum for the class.

NOTE 102 The requirements for MF-WPT4 are under consideration.

6.103 Installation

The primary device is classified according to the type of mounting:

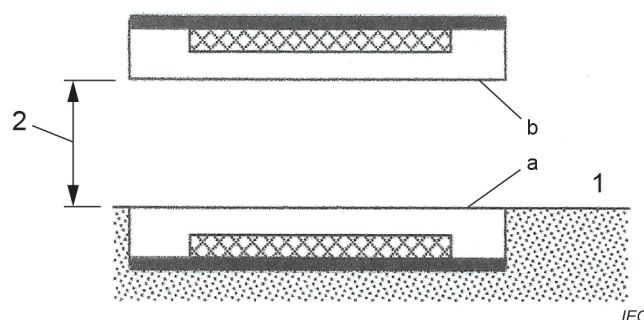
- surface mounted – see Figure 101;
- flush mounted – see Figure 102.



Key

- a primary device
- b secondary device
- 1 top of road surface
- 2 secondary device ground clearance

Figure 101 – Surface mounted



Key

- a primary device
- b secondary device
- 1 top of road surface
- 2 secondary device ground clearance

Figure 102 – Flush mounted

Primary devices not secured to the mounting surface are under consideration.

See Annex C for position within the parking spot.

6.104 Z classes

The SPC which is part of a compatibility class A supply device is classified according to the supported secondary device ground clearances as specified in Table 102.

Table 102 – Supported secondary device ground clearance range

Supply power circuit Z-class	Supported secondary device ground clearance range mm
Z1	100 to 150
Z2	100 to 210
Z3	100 to 250

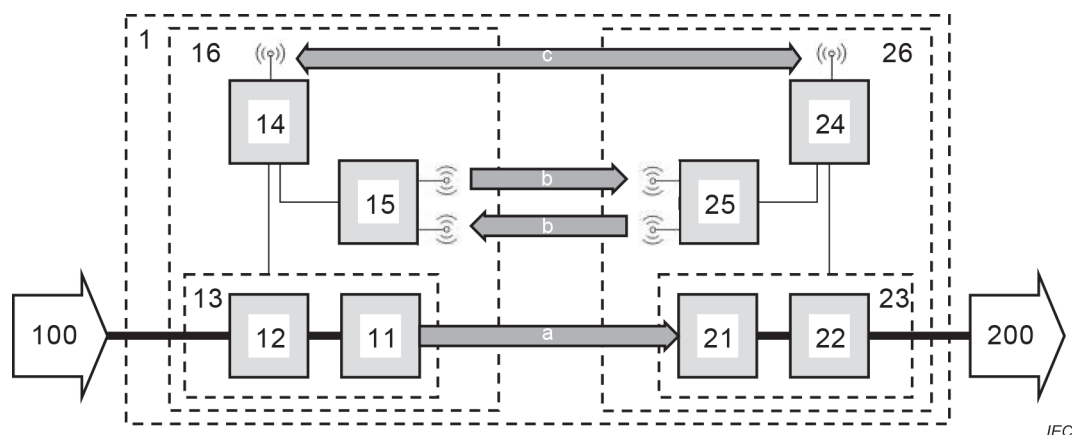
7 General supply device requirements

Clause 7 of IEC 61980-1:2020 applies except as follows:

7.1 General architecture

Replacement:

Figure 1 shows a representation for the structure of the components referred to throughout this document. Additional communication and signalling architectures to support MF-WPT activities apply according to IEC 61980-2.



Key	Name	Key	Name
1	MF-WPT system	21	secondary device
11	primary device	22	EV power electronics
12	supply power electronics	23	EV power circuit (EVPC)
13	supply power circuit (SPC)	24	EV communication controller (EVCC)
14	supply equipment communication controller (SECC)	25	EV device P2PS controller
15	supply device P2PS controller	26	EV device
16	supply device	200	RESS
100	supply network		
a	wireless power flow	b	wireless signalling
		c	wireless communication

NOTE See IEC 61980-2 for details regarding items 14, 15, 24, 25, b and c.

Figure 1 – Example of an MF-WPT system

7.2 Power transfer requirements

Additional subclauses:

7.2.101 General

Unless otherwise stated in any of the subsequent clauses of this document, requirements apply to both compatibility class A supply devices and compatibility class B supply devices and their component parts.

If an EVPC from Annex A is being tested for operation with a compatibility class B supply device candidate, for the purpose of the test, that EVPC should be treated and specified as if it were a compatibility class B EV device (see Table 108).

Procedures for verification of conformance are included in 101.1.

7.2.102 Frequency requirement

The following frequency requirements apply to both compatibility class A supply devices and compatibility class B supply devices.

For compatibility class A, the supply device shall utilize magnetic resonance to perform power transfer within the fundamental frequency range of 79 kHz to 90 kHz in accordance with ITU-R Recommendation SM.2110.1:2019, Table 1.

For compatibility class B, the supply device shall operate within the fundamental frequency range of 79 kHz to 90 kHz. Only the fundamental frequency is permitted to be used for power transfer.

For a given charging session, the operating frequency may be selected at low power to be any frequency within the system frequency range; the operating frequency shall remain fixed within $\pm 0,050$ kHz for the duration of that charging session unless the power level is reduced to meet the low power requirement.

For this purpose, low power is a power level less than or equal to 25 % of full power for the specific combination of supply device and EV device, determined as the lower of maximum input (kVA) into the supply device or the rated power out of the EVPC.

NOTE 101 While any fixed frequency in the system frequency range is allowable, the nominal operating frequency for the normative reference EVPCs is 85 kHz.

NOTE 102 In the following country, frequency variation while transferring power may be allowed under certain conditions: JP.

7.2.103 Input voltage and kVA levels

For both compatibility class A supply devices and compatibility class B supply devices, the manufacturer shall specify the input voltage range of operation and the rated input kVA.

7.2.104 Output voltage levels

7.2.104.1 Compatibility class A supply device

For a compatibility class A supply device, the normative reference EVPCs shall provide output voltages of 280 V to 420 V at maximum power levels (see 7.2.105.1).

7.2.104.2 Compatibility class B supply device

For a compatibility class B supply device, the minimum and maximum output voltages of the EVPC(s) are specified by the manufacturer.

- $V_{\min}$ is the minimum output voltage.
- $V_{\max}$ is the maximum output voltage.
- V_{range} is equal to $(V_{\max} - V_{\min})$.

7.2.105 Output power levels

7.2.105.1 Compatibility class A supply device

A compatibility class A supply device shall be able to deliver maximum power to all of the normative reference devices specified in Annex A. The conditions for maximum power transfer are given below.

When the WPT power class of the normative reference EVPC is the same as or higher than the supply device power class, the maximum power delivered occurs when the input to the supply device is the rated kVA.

When the WPT power class of the normative reference EVPC is lower than the supply device power class, the maximum power delivered occurs when output of the EVPC is at the EVPC rated power level.

7.2.105.2 Compatibility class B supply device

A compatibility class B supply device shall be able to deliver the rated output power to the EVPC(s) specified by the manufacturer of the supply device.

7.2.106 Dynamic performance

7.2.106.1 General

For both a compatibility class A supply device and a compatibility class B supply device, the following times for shutdown are required.

In the event of an emergency shutdown condition, the supply device shall ramp down its primary device coil current and stop power transfer within 1 s of the identification of emergency shutdown.

In the case of loss of communication between the EVPC and SECC, power shall be reduced to a level that is low enough to meet EMF requirements within 4 s of the loss of communication, including up to 2 s for detection of loss of communication to trigger shutdown. Power shall continue decreasing to zero watts.

When power transfer is set to 0 W or is otherwise stopped, the current in the primary device coil shall be such that all EMF requirements herein are met.

7.2.106.2 Compatibility class A supply device

For a compatibility class A supply device, during normal operation, the output power ramp-up and output power ramp-down rates shall be within the ranges in Table 103.

Table 103 – Compatibility class A supply device output power ramp rates

Normal operation	Minimum	Maximum
Output power ramp up rate	0,25 kW/s	2 kW/s
Output power ramp down rate	2,5 kW/s	(None)

The supply device input current overshoot shall remain within 10 % of its target value during ramp up and ramp down.

The supply device shall have the means to increase and decrease the delivered power to the EVPC during power transfer. The supply device makes these adjustments by adjusting the current to the primary device coil.

The supply device shall have a controller response time of 2 ms or less for controlling the current to the primary device coil during all operating conditions.

NOTE Separate but interacting control systems might exist on the supply device and EVPC (see IEC 61980-2).

Special consideration should be given about control stability in the case of an EVPC capable of making changes affecting power delivery or impedance seen by the primary device.

If the EVPC is able to make adjustments that affect power delivery or the impedance seen at the supply device, the changes shall not result in power delivery changes that exceed the above ramp-up and ramp-down rates in normal operation. The EVCC shall only request changes from the supply device during start-up and normal operation once its own control adjustments are complete. During normal operation, the EVPC shall make all changes that affect the power or the impedance seen at the primary device at a rate at 50 Hz or less so that the supply device can compensate for these changes before further impedance changes occur. If the EVPC detects an emergency or error condition, it may make changes at any rate necessary to keep within safe operating conditions.

7.2.106.3 Compatibility class B supply device

For a compatibility class B supply device, the manufacturer shall specify the normal operation ramp up and ramp down rates, the supply device input current overshoot and the control bandwidth.

7.3 Efficiency

Additional subclauses:

7.3.101 Compatibility class A supply device

A compatibility class A supply device shall support the minimum power transfer efficiency according to Table 104 when operating with a reference EVPC of the same WPT power class at its rated input kVA.

Table 104 – Minimum power transfer efficiency with compatibility class A supply device and normative reference EV device of same power class

Alignment	Minimum power transfer efficiency
At centre alignment point	85 %
Within alignment tolerance	80 %

Since compatibility class A supply devices might be rated at a WPT power level that is different from that of the EVPC to which it is being asked to provide power, provision for that power level difference is provided in the efficiency requirements as shown in Table 105.

When the supply device is the same power class or is a lower power class than the EVPC, the efficiency requirements of Table 105 apply when the supply device is operated at its rated input kVA.

When the supply device is a higher power class than the EVPC, the efficiency requirements of Table 105 apply when the output of the EVPC is the maximum rated output.

Table 105 – Minimum power transfer efficiency with compatibility class A supply device and normative reference EV device of different power classes

Alignment	Power class difference between supply device and EV device	
	One power class	Two power classes
At centre alignment point	82 %	80 %
Within alignment tolerance range	77 %	75 %

7.3.102 Compatibility class B supply device

A compatibility class B supply device is designed to operate with specific EVPCs. When operated at its rated input kVA, the efficiency shall be according to Table 106.

Table 106 – Minimum power transfer efficiency for a compatibility class B supply device and specified EVPC

Alignment	Minimum power transfer efficiency
At centre alignment point	85 %
Within alignment tolerance	75 %

7.4 Alignment

Additional subclauses:

7.4.101 Alignment tolerance area for compatibility class A supply device

The alignment tolerance area relative to the centre alignment point for the primary device of a compatibility class A supply device is a rectangle as specified in Table 107.

Table 107 – Alignment tolerance of a primary device (compatibility class A)

Axis	Alignment tolerance range mm
X	±75
Y	±100

7.4.102 Secondary device ground clearance range for compatibility class A supply device

The compatibility class A supply device shall be able to meet the performance requirements as a class Z3 supply device per Table 102.

7.4.103 Alignment tolerance area for compatibility class B supply device

The manufacturer shall specify the shape and dimensions of the alignment tolerance area relative to the centre alignment point for the primary device of a compatibility class B supply device (primary device class B) and the specific EV supply device combination. If there is more than one combination, the alignment tolerance area for each shall be specified.

7.4.104 Secondary device ground clearance range for compatibility class B supply device

Since the manufacturer will specify the EVPCs with which the class B supply device is to be tested, the manufacturer shall specify the secondary device ground clearance range for the supply device and the EV device combination. If there is more than one combination, the ground clearance range for each shall be specified.

7.5 Activities provided by WPT system

Addition:

IEC 61980-2 models the operation process for MF-WPT as a WPT session, which is organized by a sequence of activities.

These activities are executed, respectively supported, by communication between the EVCC and the SECC. The requirements for a supply device related to the execution of the activities, including hardware related requirements, are described in IEC 61980-2.

Additional subclauses:

7.101 Overall performance requirement

The expectation and requirement for both a compatibility class A supply device and a compatibility class B supply device is that it meets the applicable requirements of 7.2.102 (frequency) and 7.3 (efficiency) and the full range of variations in 7.2.103 (input voltage and kVA), 7.2.104 (output voltage from the EVPC), 7.2.105 (output power from the EVPC), and the dynamic performance requirements in 7.2.106 over the alignment range specified in 7.4.

A summary of the requirements mentioned in the above paragraph is presented in Table 108.

Table 108 – Summary requirements according to compatibility class

Reference clause/subclause	Subject		Compatibility class A requirement	Compatibility class B requirement
9	Secondary devices for test purposes		Reference devices in Annex A	Specified by manufacturer
9	Secondary device ground clearance range		100 mm to 250 mm	Specified by manufacturer
7.2.102	System frequency		79 kHz to 90 kHz (85 kHz nominal)	79 kHz to 90 kHz (85 kHz nominal)
7.2.103	Input voltage range and rated input power		Specified by manufacturer	Specified by manufacturer
7.2.104	Output voltage range		280 VDC to 420 VDC	Specified by manufacturer
7.2.105	Output power levels		At max. input kVA to supply device or max. rated output of reference EVPC, whichever occurs first	Rated power as specified by manufacturer
7.2.106	Emergency Shutdown		< 1 s	< 1 s
	Upon loss of communication		< 4 s	< 4
	Dynamic performance during normal operation	Ramp up rate	0,25 kW/s to 2,0 kW/s	Specified by manufacturer
		Ramp down rate	≥ 2,5 kW/s	Specified by manufacturer
7.3.101	Minimum power transfer efficiency with supply device and reference EVPC of same power class	At centre alignment point	85 %	
		Within alignment tolerance area	80 %	
7.3.102	Minimum power transfer efficiency with supply device and specified EVPC	At centre alignment point		85 %
		Within alignment tolerance area		75 %
7.4.101	Alignment tolerance area	X axis	±75 mm	Specified by manufacturer
7.4.103		Y axis	±100 mm	Specified by manufacturer
7.4.102 7.4.104	Ground clearance range		100 mm to 250 mm	Specified by manufacturer

The number of test combinations is very large and it would be impractical to execute them fully. The test procedure in 101.1 describes the verification process under this document.

Additional design verification tests are strongly recommended. They could uncover areas where performance might be most likely to approach the limits.

7.102 Vehicle presence detection

Unless there is a separate mechanism for detection of vehicle presence, a compatibility class A supply device shall be able to detect the presence or absence of a vehicle located over the primary device. The detection capability shall be independent of the supply device's external communication or signalling mechanism.

The use of this information is self-contained within the supply device in order to make the supply device aware that it should not respond to pairing requests from an approaching vehicle if there is already a vehicle located over that primary device.

Verification of functionality is given in 101.3.

8 Communication

Clause 8 of IEC 61980-1:2020 is applicable except as follows:

Addition:

The communication and control concept for both compatibility class A supply devices and compatibility class B supply devices are described in IEC 61980-2.

The communication and control requirements for compatibility class A supply devices are described in IEC 61980-2.

The hardware to support the communication as described in IEC 61980-2 between the EVCC and SECC is not specified in this document. See IEC 61980-2 for details.

9 Power transfer interoperability

Replacement:

Interoperability refers to WPT between a supply device and an EV device that were not specifically designed with each other, for example, WPT between devices from different vendors or devices of different power classes.

For a compatibility class A supply device, interoperability shall be verified with the normative reference EVPCs for each MF-WPT power class and applicable Z class as given in Annex A, meeting all the requirements for a compatibility class A supply device listed in Clause 7, using the procedure in 101.1.

Interoperability of a compatibility class B supply device does not apply since the supply device is meant to work with specific EVPCs. It is verified with each of those EVPCs to meet all the requirements for a compatibility class B supply device listed in Clause 7 using the procedure in 101.1.

All of the devices specified in Annex A are built using circular coil topology.

Other coil topologies exist; examples of coils using DD coil topology are shown in Informative Annex B.

NOTE Approaches to define magnetic interoperability by requirements beyond testing against reference EV power circuits are under development – see Annex D.

10 Protection against electric shock

Clause 10 of IEC 61980-1:2020 is applicable except as follows:

10.1 General requirements

Addition:

NOTE 101 For systems or equipment on board the vehicle, the requirements are specified in ISO 19363.

10.2 Degree of protection against access to hazardous-live-parts

Replacement:

IP ratings for enclosure of the primary device shall be at least IPXXD. See also 13.4.

10.3.1 Stored energy under abnormal or fault conditions

Addition:

For a supply device that consists of two or more parts connected by a cable and connector(s), where the connector can be disconnected without the use of a tool and the connection pins are accessible after disconnecting, the voltage between any combination of accessible contacts of the connector shall be less than or equal to 60 V DC or the stored energy available shall be less than 0,5 mJ one second after disconnecting.

11 Specific requirements for WPT systems

Clause 11 of IEC 61980-1:2020 is applicable, except as follows:

11.1 General

Addition before the first paragraph:

The supply device shall be able to detect any of the following errors or exceptions:

- excessive operating temperature;
- input undervoltage/overvoltage;
- input overcurrent.

If the error or exception persists, the supply device shall attempt to correct the issue in accordance with the requirements of IEC 61980-2.

NOTE Possible corrective actions include decreasing the level of power transfer or power shutdown.

11.3 Insulation resistance

Replacement of the first paragraph:

The insulation resistance with a 1 000 V DC voltage applied between all inputs/outputs connected together and the accessible parts shall be

- for a class I supply device: $R \geq 1 \text{ M}\Omega$, and
- for a class II supply device: $R \geq 7 \text{ M}\Omega$.

11.6.3 Temperature limits for material

Replacement of the second and third paragraphs:

Temperature rise during normal operation and under single fault condition shall not cause damage to current-carrying parts or adjacent parts of the supply device.

Compliance is demonstrated on a design verification basis according to 10.10 of IEC 61439-1:2020.

11.6.4 Protection against burns from heating of foreign objects

Replacement:

11.6.4.101 Touch hazards

11.6.4.101 applies to both compatibility class A supply devices and compatibility class B supply devices.

The manufacturer of the supply device shall determine and specify the "critical active area", i.e. the area in which foreign objects could be exposed to magnetic fields of sufficient strength to cause them to reach or exceed the temperature limits of

- 80 °C for metal parts bare metallic surfaces, and
- 90 °C for parts with non-metallic surfaces.

In most cases, the critical active area is above the surface of the primary device.

There are four categories of objects.

- 1) Objects which will not heat up when exposed to the magnetic fields in the critical active area.
- 2) Objects which will heat up and could exceed the temperature limits if located in the critical active area during power transfer, but which will also cool to below the temperature limit within a few seconds after power transfer has ceased. These will likely be small objects which might be difficult to detect.
- 3) Objects which will heat up and could exceed the temperature limits if located in the critical active area during power transfer, but which will also cool to below the temperature limit within 10 s after power transfer has ceased.
- 4) Objects which will heat up and exceed the temperature limits if located in the critical active area during power transfer and will still exceed the temperature limits after 10 s after power transfer has ceased.

Only category 4 objects are categorized as touch hazards for the purpose of foreign object detection.

NOTE 101 The requirements apply to protect someone from touching the foreign objects. This touch requirement applies only to objects which are accessible at that time. Objects under the vehicle are not considered accessible. In the usual case associated with this document, such foreign objects of concern would be under the vehicle when parked, or above or adjacent to the primary device prior to the vehicle being present or after the vehicle has left the parking spot.

NOTE 102 The time mentioned in category 2 allows for an intrusion detection system, where a person is detected to be reaching under the vehicle.

NOTE 103 The 10 s mentioned in category 3 allows for power transfer to cease and the vehicle to be moved away from the charging spot.

The supply device shall have a foreign object detection (FOD) facility capable of detecting objects in category 4. Upon detection of a category 4 object, the FOD facility shall cause power transfer to cease.

Compliance is tested in accordance with 101.2.

Also see 17.102.

11.6.4.102 Protection against heat and fire

11.6.4.102 applies to both compatibility class A supply devices and compatibility class B supply devices.

The supply device shall not cause foreign objects to become a fire hazard. For the purposes of 11.6.4.102, a fire hazard is defined as a hazard which causes combustion.

Foreign objects that may become a fire hazard shall be detected and the system shall shut off or reduce power transfer to prevent ignition.

Compliance is tested in accordance with 101.2.

11.8 Protection from electromagnetic field

Replacement:

11.8.101 General

A WPT system shall not cause human exposure to electromagnetic fields above the limits from applicable ICNIRP guidelines as a result of WPT operation. The area inside the vehicle cabin and outside the envelope of the vehicle exterior (front, sides, rear) down to the ground level is covered in ISO 19363:2020 (protection areas 2 and 3). See Figure 103.

The area underneath the vehicle, ISO 19363:2020 protection area 1, delimited by the envelope of the vehicle exterior, is the responsibility of the SPC.

For purposes of a test bench setup, protection area 3 is considered to be the region directly above the mimic plate; protection area 1 is considered to be the region underneath the mimic plate; and the remaining region to the sides of the test bench is considered protection area 2.

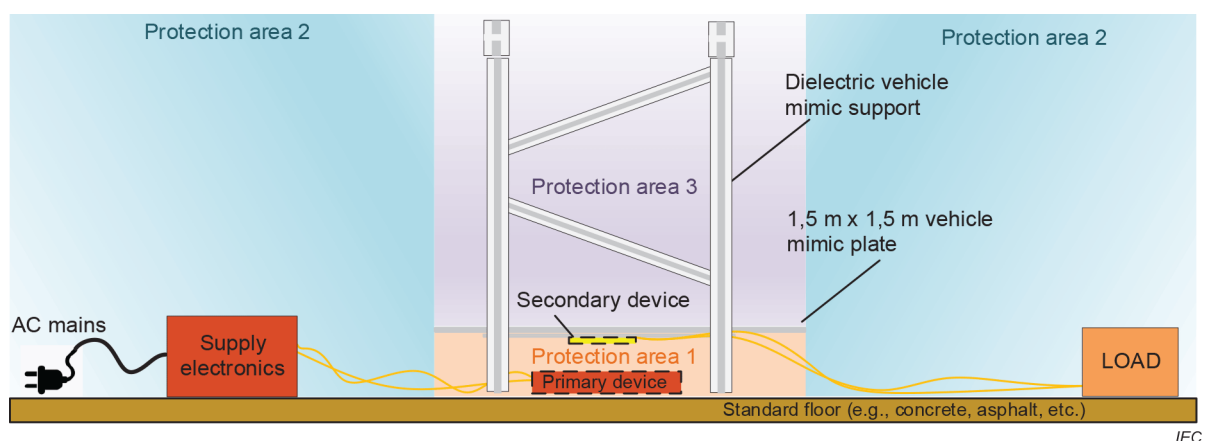


Figure 103 – Test bench protection areas

11.8.102 Requirements for protection of persons against exposure to hazardous electromagnetic fields

In accordance with ICNIRP Guideline 2010, the basic restrictions in Table 2 of ICNIRP Guideline 2010, or the reference levels, as in Table 4 of ICNIRP Guideline 2010, shall be met.

NOTE Local regulations might specify more restrictive requirements.

Since protection area 1 is under the vehicle and is typically not accessible, the need for protection of persons becomes a concern only if the electromagnetic fields are greater than those that meet the ICNIRP limits when a human is under the vehicle. If the fields exceed the ICNIRP limits in protection area 1, additional measures shall be implemented in one of the following ways:

- 1) active or passive access control, which prevents a person from entering or placing any appendage in the region where the ICNIRP limit is exceeded;
- 2) detection and shutdown of the MF-WPT system before ingress into the region where the ICNIRP limit is exceeded.

11.8.103 Requirements to protect the functionality of cardiac implantable electronic devices (CIEDs)

According to ISO 14117, the safe electromagnetic field limit for cardiac implantable electronic devices (CIEDs) is based on the maximum allowed voltage induced in a 225 cm² loop. ISO 14117 indicates that the maximum allowed induced voltage, $V_{\text{MAX_INDUCED_RMS}}$, is set

such that $V_{\text{MAX_INDUCED_RMS}} = \frac{3\sqrt{2}}{2} \text{ mV} \times \text{frequency (kHz)}$, for example 180,31 mV RMS at 85 kHz. By converting this to a field level, the conservative maximum field level of 15,0 µT or 11,9 A/m RMS for 79 kHz to 90 kHz for a 225 cm² loop can be determined. This magnetic field limit is considered a CIED reference level, similar to what exists for human exposure reference levels, and is based on the implied CIED basic restriction of induced lead loop voltage.

Either the CIED basic restriction or the CIED reference level shall be met. Conservative compliance to the CIED reference level can be demonstrated using a standard 100 cm² field probe with three axes such as those indicated in IEC 61786-1 and averaging four designated locations around any maximum measurement exceeding 15,0 µT RMS according to procedures in ISO 19363:2020, Annex D. The field level is conservatively taken in all three axes and is designated as the magnitude (root sum squared) of the X, Y, and Z axes (i.e., $|B_{\text{FIELD}}| = \sqrt{B_X^2 + B_Y^2 + B_Z^2}$). The CIED basic restriction or reference level shall be met in protection areas 2 and 3 for any realistic CIED lead loop position associated with a reasonably foreseeable human body torso position.

Determining compliance with basic restrictions is more complex than compliance with reference levels, but in the event that reference levels are not met, compliance with basic restrictions will satisfy the safety requirement.

If the MF-WPT fields are modulated, substantially non-sinusoidal, or include overshoot during amplitude transitions, the CIED assessments should be performed using peak limits equal to the RMS limits times 1,41.

11.8.104 Determining compliance with required field levels

Determining compliance should be done under the following conditions:

- maximum misalignment between the secondary device and the primary device;
- maximum ground clearance;
- transfer of rated output power at a low state of charge.

Using a 100 cm² field probe according to IEC 61786-1, the magnitude of the fields can easily be determined.

In protection area 1, if the field is greater than the limit in 11.8.102, either

- a) determination of compliance with the basic restriction can be undertaken using appropriate numerical simulation methods (see ISO 19363:2020, Annex D),
- b) active or passive control can be implemented to prevent a person or appendage from entering regions where the limit is exceeded, or
- c) a human detection system can be implemented that shuts off or reduces power transfer to a safe level.

In protection areas 2 and 3, if the field is less than the human limit in 11.8.102 but greater than the CIED limit in 11.8.103 (using an average of four points according to ISO 19363:2020, Annex D), compliance with the basic restriction for CIEDs is demonstrated if the induced voltages in a 225 cm² pacemaker lead loop does not exceed $\frac{3\sqrt{2}}{2}$ mV × frequency (kHz) in

RMS, for example 180,31 mV RMS at 85 kHz, when the lead loop is located in a reasonable orientation and position reflecting a human position in protection areas 2 and 3.

If compliance with human or CIED basic restrictions are not met, a method to prevent intrusion (e.g., a barrier) or a human detection system can be implemented to shut off or reduce power transfer to a safe level in the appropriate region.

When performing compliance testing using a test bench setup (see 101.1.3), the mimic plate shall be considered equivalent to the vehicle body shown in ISO 19363:2020, Annex D; measurements shall be taken 20 cm from the vertical projection of the edge of the mimic plate and follow procedures in ISO 19363:2020, Annex D.

12 Power cable requirements

Replacement:

12.101 Power cable

For the purposes of this document, the power cable is the cable which connects the SPC to the source of electricity.

The power cable shall be rated to carry the voltage levels and current levels which it is exposed to in operation and be appropriate for the environmental and service factors to which it will likely be exposed.

Compliance to be verified by inspection.

12.102 Connecting cable

Connecting cables shall be constructed in a manner that is appropriate for the environmental and service conditions, as well as the voltage and current capabilities to which it is exposed in normal service.

Compliance to be verified by inspection.

If a power cable or a connecting cable is used in a manner that could lead to drive over, it shall be subjected to the drive-over test in 14.2.101. Installation with the use of a mechanical protective structure, such as conduit, and possibly buried within the pavement, should be considered.

13 Constructional requirements

Clause 13 of IEC 61980-1:2020 is applicable except as follows:

13.1 Supply device dimensions and installation requirements

Replacement:

The mounting height of the under-vehicle package above the parking or road surface shall not exceed 70 mm.

Surface characteristics of the under-vehicle package may be subject to local regulations.

13.4 IP degrees

Replacement:

The IP degree for the enclosure of the under-vehicle package for surface mounted and flush mounted devices shall be as follows:

- the minimum IP degrees shall be IP 65;
- the minimum IP degrees in public road installation shall be IP 69K according to ISO 20653 as installed.

The minimum IP degrees for the remaining package(s) shall be as follows:

- for indoor use: IP 41;
- for outdoor use: IP 44.

Compliance is checked by test in accordance with IEC 60529.

NOTE In the following countries, the UL articulated finger probe is used according to national regulations: US, CA.

14 Strength of materials and parts

Clause 14 of IEC 61980-1:2020 apply except as follows:

14.2 Verification of mechanical strength for the enclosure of the supply device

Replacement:

Enclosures, other than under-vehicle-package, shall be subject to the applicable tests in accordance with IEC 61439-7:2018, 10.2.701.

The under-vehicle-package shall be subject to the test in 14.2.101.

Additional subclause:

14.2.101 Vehicle drive-over test

Vehicle drive-over test only applies to an under-vehicle package and its associated cables.

The under-vehicle package, including cables, shall be installed on or in a flat concrete floor as specified in the manufacturer's documentation. The test shall be performed as it should be installed, but not during the transfer of power.

A crushing force shall be applied to the under-vehicle package and to the cable with a wheel load of 5 000 N by a conventional automotive tire, P225/75R15 or an equivalent tire suitable for the load, mounted on a steel rim and inflated to a pressure of $(2,2 \pm 0,1)$ bar. The wheel shall be rolled over the main part of the under-vehicle package and the cable at a speed of (8 ± 2) km/h.

For the under-vehicle package:

- drive-over starts from one side of the device over the centre in each direction (X and Y) to expose the device surface to the above specified crushing force;
- as a next step, conduct same test with the drive direction turned by 45° , i.e., a diagonal direction across the device across opposite corners.

For those applications where there is a need to protect the under-vehicle package from heavy vehicles (such as transit buses), the drive-over test shall be performed with a wheel load of 15 000 N with tires in the range of 275/70 R22.5 at 8 bar (typical for European and Asian transit buses) or 305/70 R22.5 inflated to a pressure of $(2,2 \pm 0,1)$ bar. The wheel shall be rolled over the main part of the under-vehicle package and the cable at a speed of (8 ± 2) km/h. The crushing force shall be applied four times:

- drive-over starts from one side of the device through centre followed by the other side in each direction (X and Y) to expose whole device surface with the above specified crushing force;
- as a next step, conduct same test with the drive direction turned by 45° , i.e., a diagonal direction across the device.

To test the cable, place the cable as specified in the installation manual, including any protective conduits. If not specified, the cable should be laid straight and flat.

The crushing force specified (depending on the application as described above) should be applied twice perpendicular to the cable at the same location.

There shall be no severe cracking, breakage, or deformation to the extent that

- live parts are made accessible to contact by the test probe of degree IPXXD according to IEC 60529,
- the integrity of the enclosure is defeated so that acceptable mechanical or environmental (degrees of) protection is not afforded to the internal parts of the device,
- there is interference with the operation, or function of the device,
- the device or its cable clamp does not provide adequate strain relief for the cable,
- the creepage distances and clearances between live parts of opposite polarity, live parts and accessible dead or earthed metal are reduced below the values designed in accordance with 13.6 of IEC 61980-1:2020,
- other evidence of damage that could increase the risk of fire or electric shock occurs, and
- the accessory does not comply with a repeated dielectric test in accordance with 11.4 of IEC 61980-1:2020.

15 Service and test conditions

Clause 15 of IEC 61980-1:2020 is applicable.

16 Electromagnetic compatibility (EMC)

Clause 16 of IEC 61980-1:2020 is applicable, except as follows:

16.1 Load and operating conditions

Additional subclause:

16.1.101 Clarification of use of the terms class A or class B in Clause 16

When a reference to class A or class B equipment is made in IEC 61980-1:2020, Clause 16, or in IEC 61980-3, Clause 16, it is referring to equipment for industrial environments (class A) or for residential environments (class B).

16.3 Disturbance requirements

16.3.2.3 Voltage fluctuation and flicker

Addition after the second paragraph:

Testing shall be done both in a standby mode and an active mode. The system shall be at a stable operating temperature.

For the tests during an active mode, monitor the results during start-up to full power, running at full power for several minutes, transition to half power, running at half power for several minutes and transition to power off.

Additional subclause:

16.3.101 Test procedure – Radiated emissions for the power transfer function

16.3.101.1 General

The method for testing to the limits in IEC 61980-1:2020, 16.3.3.4 and 16.3.3.5, shall be performed in accordance with regional regulatory requirements. The following are the test setup recommendations for MF-WPT systems.

The MF-WPT system test shall be performed on an accredited open area test site (OATS), semi-anechoic chamber (SAC), or absorber-lined shielded enclosure (ALSE), which has been certified for radiated testing in the frequency range being tested (e.g., 9 kHz to 30 MHz). The test site shall have a metal floor and metal turntable with a radius of at least 1,9 m capable of rotating the MF-WPT equipment under test (EUT). The initial scans shall be performed using a turntable angle step size no greater than 22,5° for each antenna orientation. Once the maximum emission is found using the coarse step size, a more precise measurement of the maximum emission may be determined by reducing the turntable angle step size.

16.3.101.2 Test bench setup

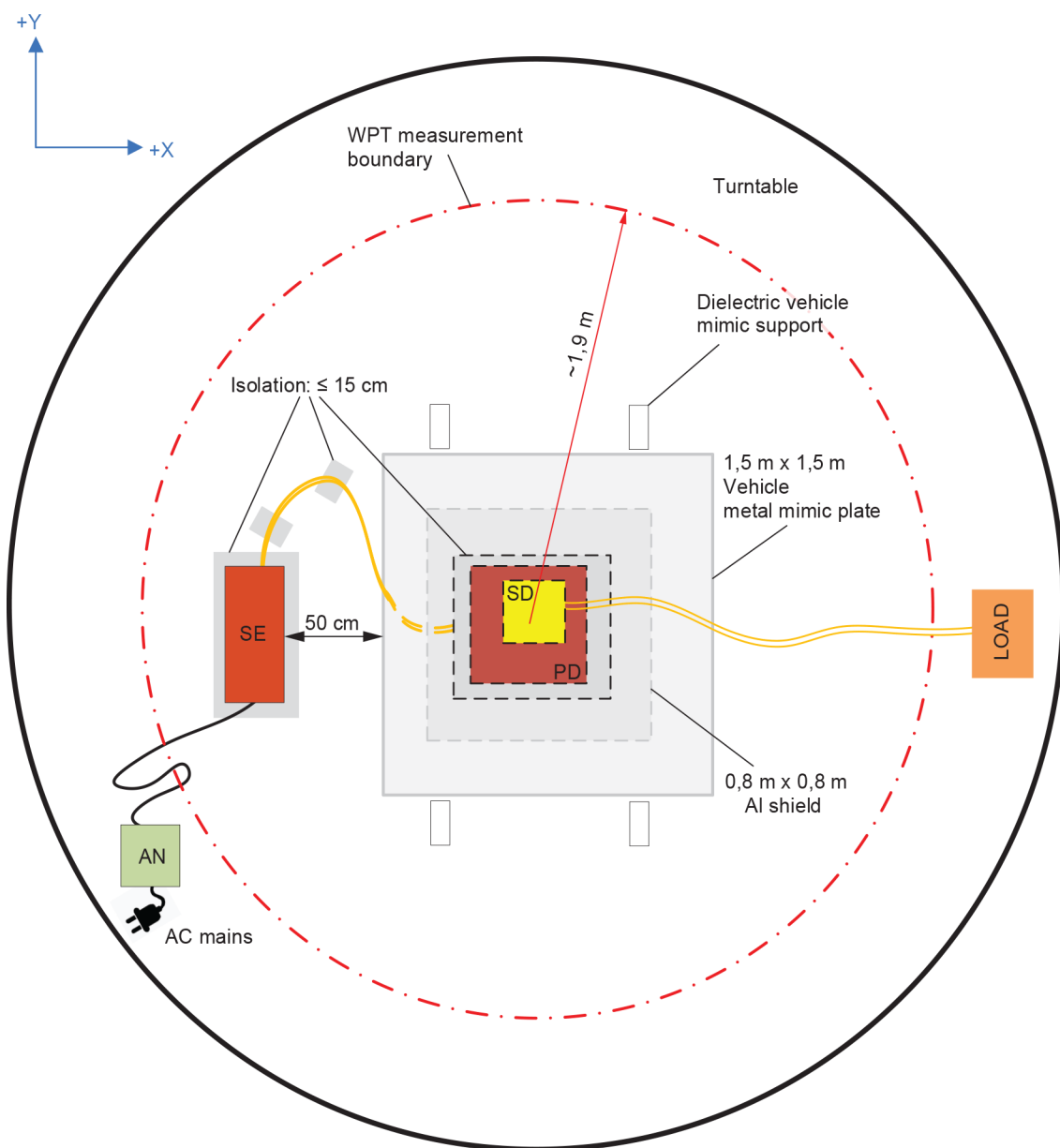
When testing using a test bench setup, the following requirements apply.

- For radiated emissions, the various EUT units should be arranged such that the size of the test volume is minimized, while still complying with typical installations and with the other requirements in this document.
- The primary device may be centred in the EUT ring, which is centred on the turntable. The secondary device is shifted for offset conditions.
- The EUT shall be electrically isolated from the metal floor.
- The EUT shall at least be tested at full power rating to a load representative of the most typical condition.

- The EUT shall at least be tested with the maximum offset and ground clearance conditions.

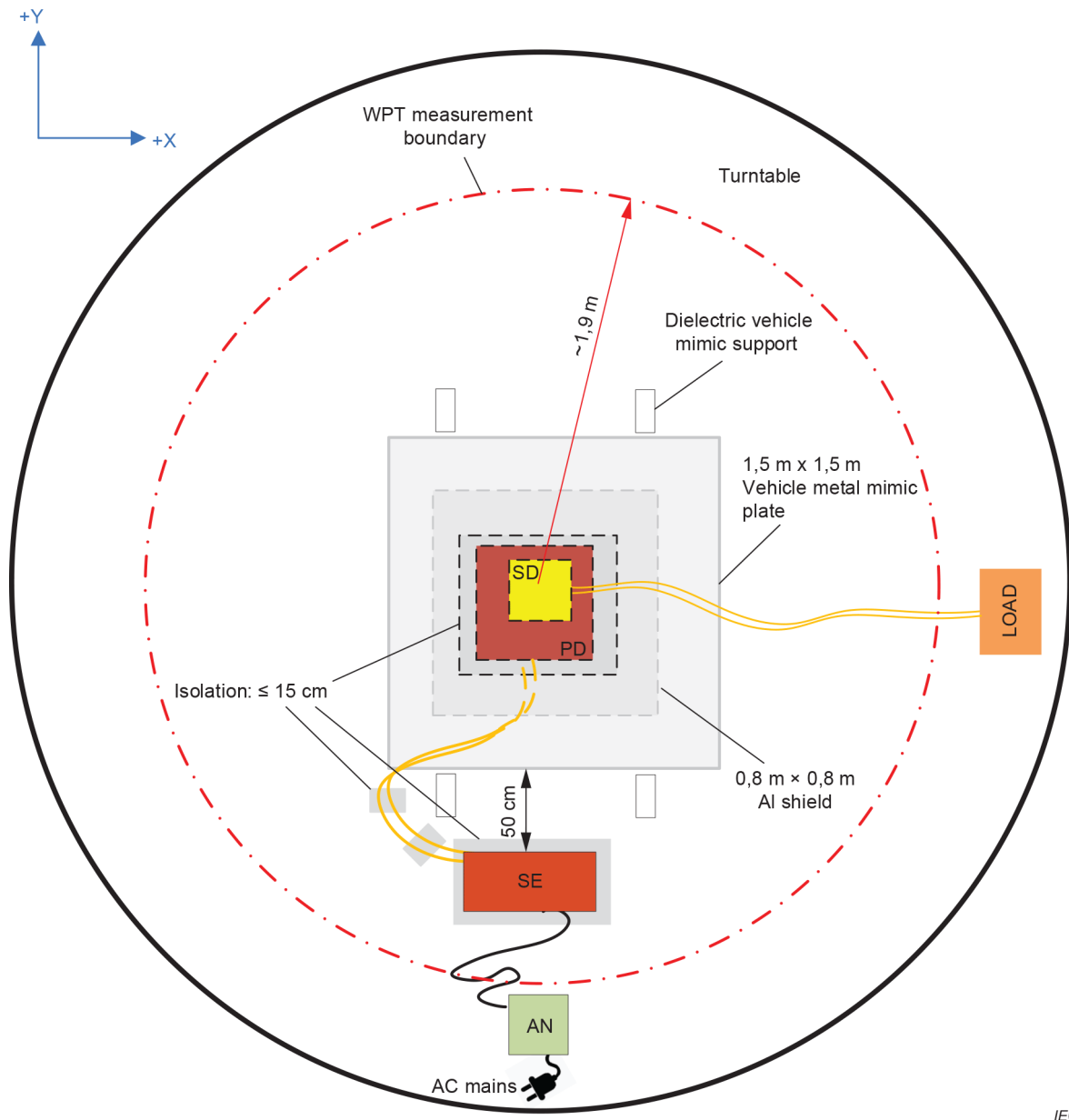
Figure 104 and Figure 105 show top views of two versions of the recommended test bench setup for radiated emissions testing. Within the figures, the following acronyms are used:

- PD – primary device;
- SD – secondary device;
- SE – supply electronics;
- AN – artificial mains network [and/or common mode absorption device (CMAD)].



IEC

Figure 104 – Example of test bench setup (version 1) – View from above



IEC

Figure 105 – Example of test bench setup (version 2) – View from above

Figure 106 shows the side view of the setup shown in Figure 104.

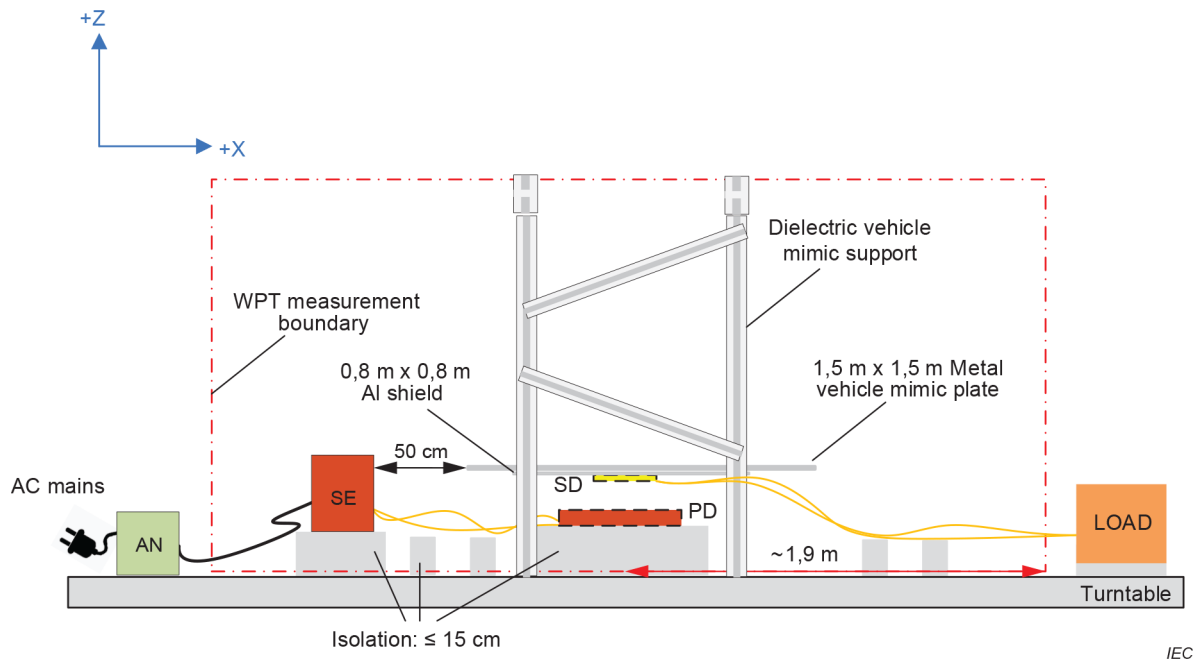


Figure 106 – Side view of test setup shown in Figure 104

The following are setup details for consideration.

- A measurement distance of 10 m from the EUT outer ring (typically 1,9 m fixed radius) is recommended.
- The secondary device and mimic plate are shifted relative to the primary device to achieve offset conditions.
- The entire EUT is electrically isolated and raised up to 15 cm off the turntable. Since the primary device can sometimes have a large metal ground plate, which can inadvertently be capacitively coupled to the test site ground plane, it is recommended that the primary device be raised near 15 cm. The isolation under the load is to be used only if necessary.
- Use of an artificial mains network (AN) and/or common mode absorption device (CMAD) is recommended on the AC mains feed to the supply device for radiated emissions testing only.
- The position of the supply electronics (SE) is recommended to be 50 cm from the mimic plate; however, the distance may be modified to represent a setup designated as typical by the manufacturer.
- The load and AN may be placed inside the EUT ring as long as they are not a source or cause of measured emission.
- Filters such as common mode chokes may be used to suppress emissions sufficiently from added cabling when using an electronic or resistive load.

16.3.101.3 Vehicle test setup

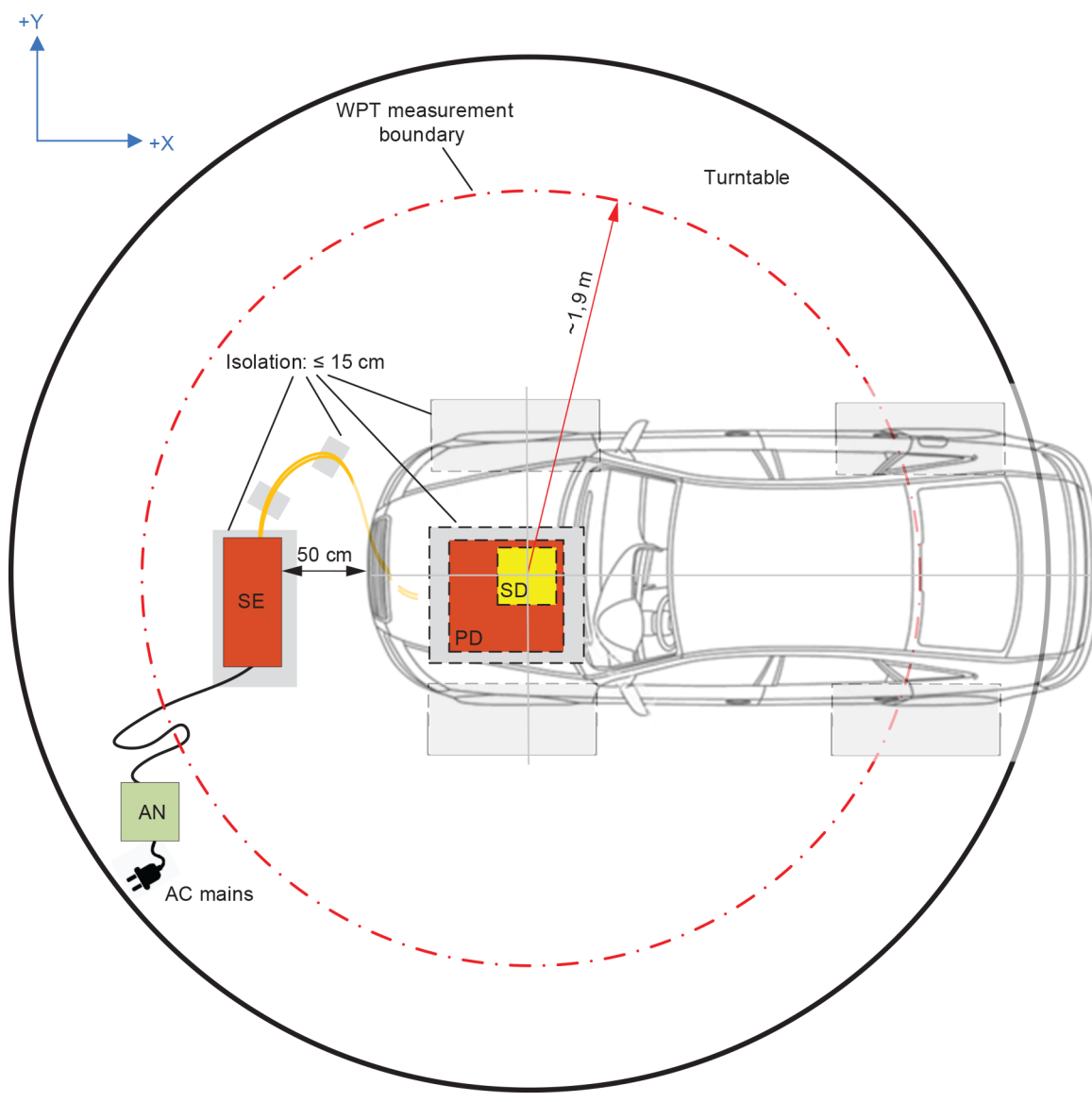
When testing using a vehicle test setup, the following requirements apply.

- For radiated emissions, the various EUT units should be arranged such that the size of the test volume is minimized while still complying with typical installations and with the other requirements in this document.
- The secondary device may be centred in the EUT ring, which is centred on the turntable. The primary device is shifted for offset conditions.
- The EUT shall be electrically isolated from the metal floor.
- The EUT shall at least be tested at full power rating to a load representative of the most typical condition.

- The EUT shall at least be tested with the maximum offset and ground clearance conditions.
- When the battery of the vehicle being charged has a reasonably large capacity compared to the amount of power delivered to the battery combined with consideration for the radiated emission scan time, the battery of the vehicle shall be used as the real-load of the MF-WPT system with a state-of-charge that ensures the system is operating at full power during the entire scan time. In the event that the battery capacity of the vehicle is too small to practically perform measurements, then the battery of the vehicle should be disconnected from the output and replaced with an equivalent load such as that used in a test bench setup.

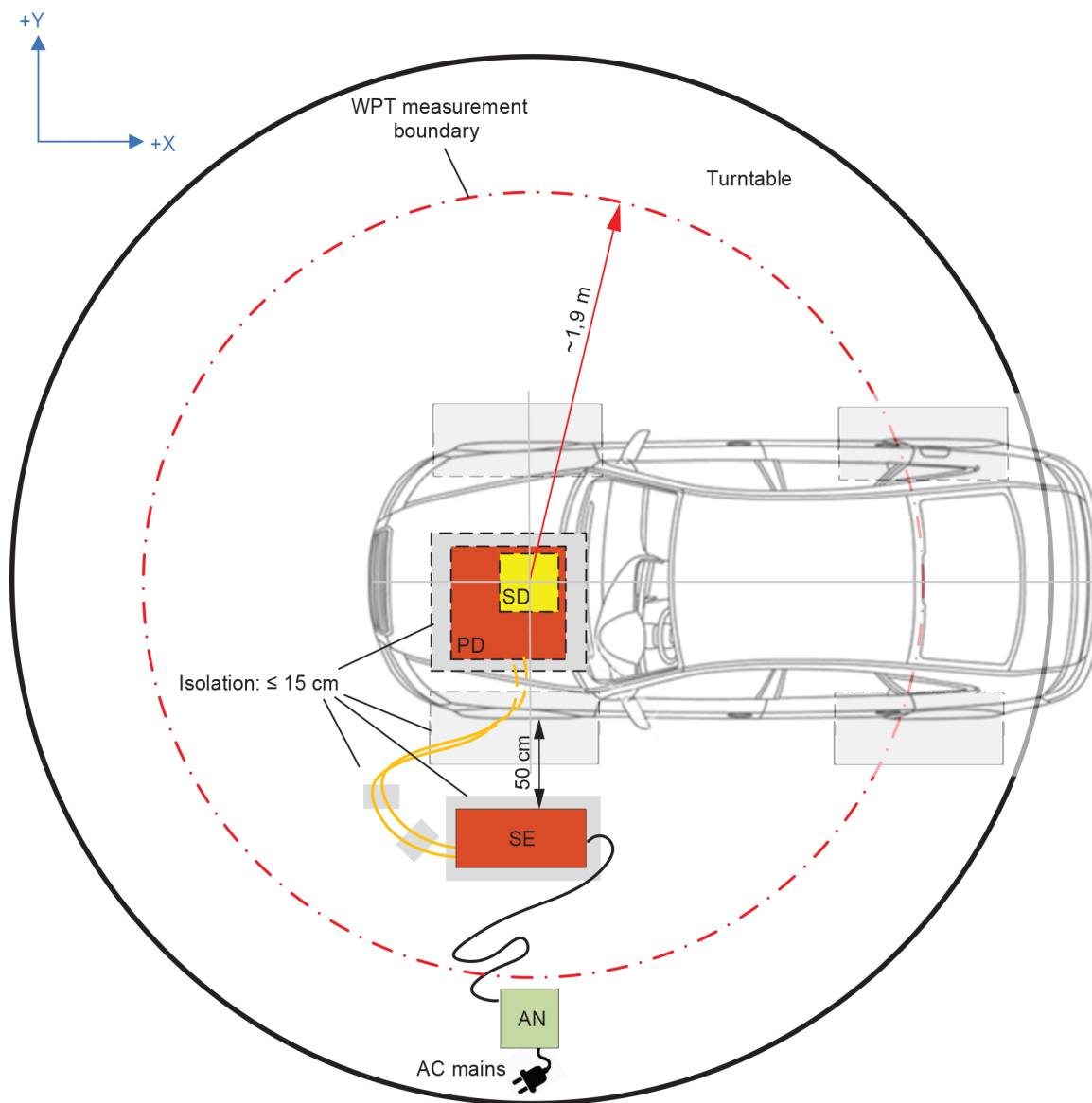
Figure 107 and Figure 108 show top views of two versions of the recommended vehicle test setup for radiated emissions testing. Within the figures, the following acronyms are used:

- PD – primary device;
- SD – secondary device;
- SE – supply electronics;
- AN – artificial mains network [and/or common mode absorption device (CMAD)].



IEC

Figure 107 – Example of vehicle test setup (version 1) – View from above



IEC

Figure 108 – Example of vehicle test setup (version 2) – View from above

Figure 109 shows the side view of the setup shown in Figure 107.

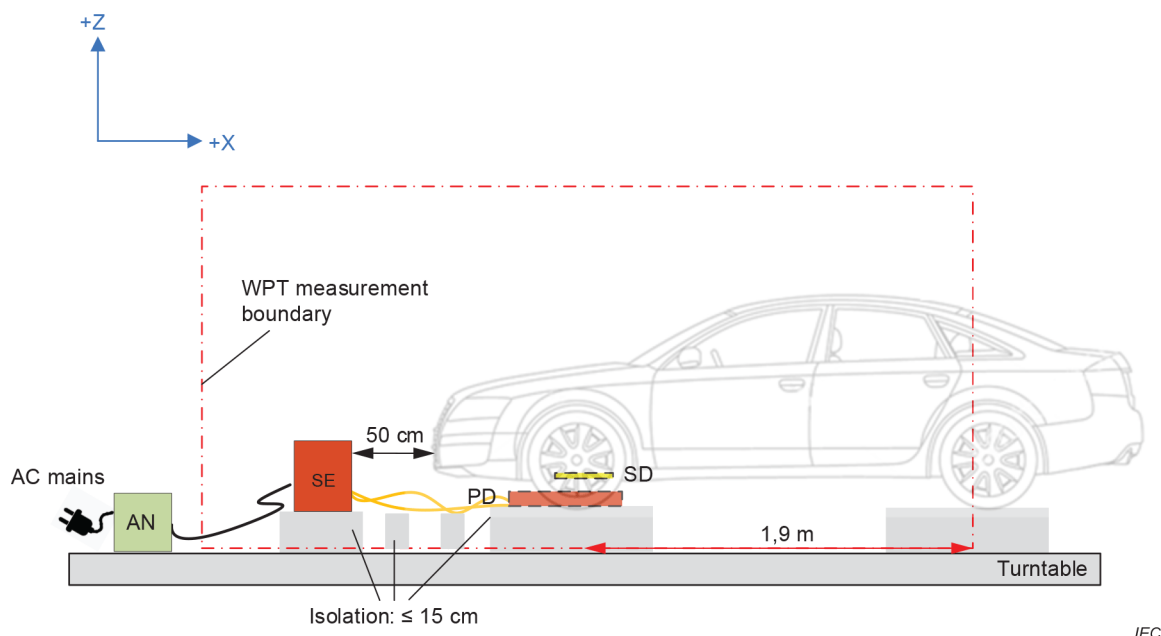


Figure 109 – Side view of test setup shown in Figure 107

The following are setup details for consideration.

- A measurement distance of 10 m from the EUT outer ring (typically 1,9 m fixed radius) is recommended.
- The entire EUT is electrically isolated and raised up to 15 cm off the turntable. Since the primary device can sometimes have a large metal ground plate, which can inadvertently be capacitively coupled to the test site ground plane, it is recommended that the primary device be raised near 15 cm.
- If metal jacks or other means are used to raise the vehicle, these shall be electrically isolated from the metal floor/turntable.
- Use of an artificial mains network (AN) and/or common mode absorption device (CMAD) is recommended on the AC mains feed to the supply device for radiated emissions testing only.
- The position of the supply electronics (SE) is recommended to be 50 cm from the vehicle; however, the distance may be modified to represent a setup designated as typical by the manufacturer.
- If a representative load is used in place of charging the vehicle battery, the load is not considered part of the EUT. It is recommended that the load be placed in a manner that ensures it is not a source of radiation.

17 Marking and instructions

Clause 17 of IEC 61980-1:2020 is applicable except as follows.

Additional subclauses:

17.101 Marking of geometric centre

In order to facilitate proper installation of the primary device in the parking space, one of the following means shall be provided:

- permanent marking for each of the 4 faces and the surface which serve as visual indicators of the geometric centre of the primary device, in combination with an indicator for direction of forward travel;

- stencil in size of the primary device providing a visual indicator of the geometric centre of the primary device in combination with an indicator for direction of forward travel.

17.102 Parking spot signage

The parking spot should have signage with the following or similar warnings:

- magnetic fields in use while charging;
- objects remaining after the vehicle has left may be hot and might cause a burn if touched.

17.103 Installation manual

The manufacturer shall provide an installation manual which lists the information that is also on the product label, all necessary safety and regulatory information and specifics about proper installation of the SPC, including location, electric supply protection and mechanical mounting instructions.

The manual shall state that a primary device that is secured to the surface shall only be removable with a tool.

17.104 User manual

The manufacturer of compatibility class B SPC shall provide a user manual which lists the information that is also on the product label, all necessary safety and regulatory information and specifics about proper use of the equipment including the specific primary devices and EVPCs which will operate correctly with this supply power circuit.

Additional clause:

101 Test procedures

101.1 Power transfer and interoperability performance

101.1.1 General conditions

For compatibility class A supply devices, the test procedures for power transfer performance, including interoperability testing, shall be performed on a test bench. The supply side being tested shall include the necessary communication components to implement the supply side requirements of IEC 61980-2.

For compatibility class B supply devices, the test procedures for power transfer performance of compatibility class B supply devices should be performed on a test bench but can be performed with the specified EVPC installed on a vehicle. Communication components to verify manufacturer specified performance compliant with Clause 7 shall be included for both the supply side and the vehicle side.

Power transfer and interoperability performance tests shall be executed only after the system has warmed up (a minimum of 5 min at full power) and the system temperature is stable.

101.1.2 Test devices and interoperability

101.1.2.1 Compatibility class A supply devices

With a compatibility class A supply device under test, the reference EVPCs specified in Clause 9 shall be used.

Compliance is checked by verifying performance with all the EVPCs specified in Clause 9.

In addition to the reference EVPCs, the test configuration shall include additional components that implement the requirements of IEC 61980-2 for the vehicle side. It is understood that the supply device being tested contains the required communication capability.

101.1.2.2 Compatibility class B supply devices

For a compatibility class B supply device being tested, the manufacturer shall specify the EVPC(s) to be used, according to Clause 9.

101.1.3 Test bench description

The test bench shall be fabricated from non-metallic elements except as listed below.

The test bench incorporates provisions to accommodate

- a primary device (part of the unit under test),
- a secondary device, and
- a vehicle mimic plate (1,5 m × 1,5 m steel) mounted immediately above an aluminium shield immediately above the secondary device; the thickness of the mimic plate is 0,7 mm to 1 mm. The shield is as specified in the annexes for each secondary device for testing compatibility class A supply devices, or as specified by the manufacturer for testing compatibility class B supply devices with their specified EVPCs.

The relative position of the primary and secondary devices shall be changeable to facilitate alignment tolerance and ground clearance tests.

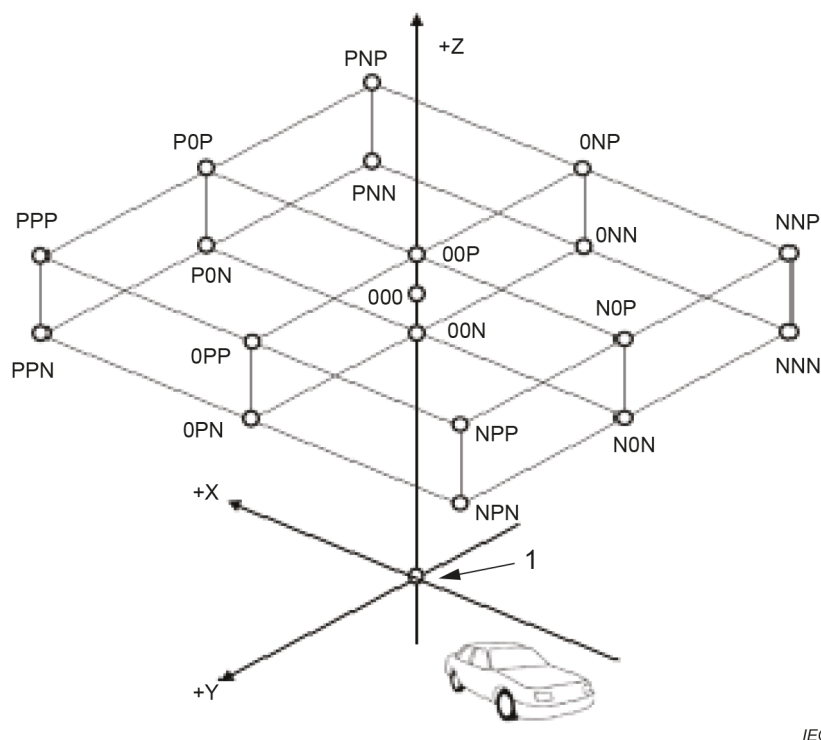
Additional equipment is needed to run the tests, such as an electronic load (to replace the vehicle battery for testing purposes) and necessary meters and computers capable of exercising the system.

101.1.4 Misalignment condition for power transfer performance evaluation

The tests in 101.1 shall be performed in the alignment positions described in Figure 110.

Table 109 shows positions for the alignment tolerance area given in 7.4.101 and the secondary device ground clearance for primary devices which are part of compatibility class A supply devices and the reference EVPCs.

In order to have an equivalent table for primary devices which are part of a compatibility class B supply device, the manufacturer shall specify the alignment tolerance dimensions, the shape and the ground clearance range of the EVPC which is being tested and from that shall generate a table similar to Table 109.

**Key**

- 1 reference point – the point on the surface under the primary device below the centre alignment point of the primary device

Figure 110 – Illustration of test positions

The X and Y offset values are relative to the Z axis at the centre alignment point of the primary device, as viewed from above. The volume delimited by the corners (NPN and NPP, NNN and NNP, PNN and PNP, and PPN and PPP) represents the possible secondary device positions for the test. The direction of movement to any given point is dependent on whether the primary device or the secondary device is being repositioned.

In describing the positions shown in Figure 110, the first letter applies to the X axis, the second letter to the Y axis and the third letter to the Z axis. For each axis, N represents the position with the most negative offset value, 0 is the midpoint position and P represents the position with the most positive offset value. See Table 109 for the alignment offset values for primary devices which are part of a compatibility class A supply device.

Table 109 – Alignment positions and offset values for primary devices which are part of compatibility class A supply devices

Position no. X Y Z	Offset value ^a mm				
	X position	Y position	Secondary device Z class		
			Z1	Z2	Z3
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 P		0	150	210	250
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

NOTE The shaded cells are an example of the quadrant used in the test plan shown in 101.1.5.3.

^a The offset values in X and Y are relative to the centre alignment point. The value in Z is relative to the ground surface.

The matrix of test positions has 19 test positions listed. Under circumstances where symmetrical results across quadrants are reasonably expected, such as with a circular primary device and a circular secondary device, testing can be reduced to only one quadrant. In order to take advantage of the reduced number of test points, symmetry of results shall be demonstrated.

101.1.5 Compatibility class A supply device performance and interoperability tests

101.1.5.1 General

As described in 101.1.2.1, the performance test is set up with the supply device under test and all of the required EVPCs (one at a time). The verification of performance with all of the specified EVPCs is used as verification of interoperability.

Test 1 verifies the nominal operational conditions, while the iterative tests in test 2 satisfy the interoperability criteria.

The test conditions are established by the test engineer. System operation is controlled using the communication as required in IEC 61980-2.

101.1.5.2 Compatibility class A supply device test 1

Test 1 is the initial test for each supply device using one EVPC of the highest WPT class.

- 1) The operating frequency is set to a fixed frequency specified by the manufacturer or determined by the test engineer with guidance from the manufacturer. The frequency shall be within the allowable frequency range of 79,0 kHz to 90,0 kHz. Record the frequency.
- 2) The input voltage to the supply device is set to nominal. Record the input voltage.
- 3) Set the X,Y,Z position to 0,0,0. Record the X,Y,Z position.
- 4) Set the output voltage to the midpoint of the output voltage range (350 V) as specified in 7.2.104.1. Record the output voltage.
- 5) The EVPC requests full power as described in 7.2.105.1. Monitor the ramp rate by starting a timer upon the request and stopping the timer upon reaching full power. Calculate and record the average ramp up rate.
- 6) When the system is in steady state at full power, record the input power and the output power, calculate and record the efficiency.
- 7) The test operator causes the EVPC to communicate an emergency in order to trigger an emergency stop power test. Monitor the emergency stop power timing by starting a timer upon the emergency signal and then at the point where the input power level creates a magnetic field strength at the surface of the supply device (or adjacent to it) that is equal to or lower than the EMF safe level. This level can be determined in terms of input power by prior testing. Record the time to achieve EMF safe level. Confirm that input power goes to zero.
- 8) The EVPC requests full power as described in 7.2.105.1. Once stable, interrupt the Wi-Fi communication signal at the EVPC. Monitor and record the elapsed time for the supply device to acknowledge the loss of communication and the elapsed time until the magnetic field is equal to or lower than the EMF safe level.
- 9) Request zero power.
- 10) Set the output voltage to the minimum of the output voltage range (280 V).
- 11) The EVPC requests full power as described in 7.2.105.1.
- 12) When the system is in steady state at full power, record the output voltage, the input power and the output power. Calculate and record the efficiency.
- 13) Request zero power.
- 14) Set the output voltage to the maximum of the output voltage range (420 V).
- 15) The EVPC requests full power as described in 7.2.105.1.
- 16) When the system is in steady state at full power, record the output voltage, the input power and the output power. Calculate and record the efficiency.
- 17) Request zero power.

End of test 1.

101.1.5.3 Compatibility class A supply device test 2

101.1.5.3.1 General

Test 2 is executed with the values from Table 110 below, in the order determined by the test engineer, as long as a test for each row is executed. The test matrix in Table 110 assumes symmetry, so only one quadrant is verified. If there is not symmetry, Table 110 should be extended to cover the full XYZ range.

The positions described in Table 110 for XY_{test} are offset positions along the X and Y axes from the centre alignment point of the primary device and the secondary device.

After performing tests for one of the rows with maximum XY offset, perform the same tests with +3°yaw and with –3°yaw of the secondary device axes relative to the primary device axes.

- 1) Select a row from Table 110 to establish the test positions (XY_{test} and Z_{test}) and output voltage (V_{test}) to be used in steps 2) through 7).
- 2) The operating frequency is set to a fixed frequency specified by the manufacturer or determined by the test engineer with guidance by the manufacturer. The frequency shall be within the allowable frequency range of 79,0 to 90,0 kHz. While it is required that it remain fixed for each charge session, it is permissible to change it between tests if necessary. Record the frequency.
- 3) The input voltage to the supply device is set to nominal. Record the input voltage.
- 4) The Z position is set to Z_{test} for the EVPC under test. Record Z_{test} .
- 5) The X,Y position is set to XY_{test} . Record XY_{test} .
- 6) Set the output voltage to V_{test} . Record V_{test} .
- 7) The EVPC requests full power as described in 7.2.105.1. When the system is in steady state at full power, record the input power and the output power, calculate and record the efficiency.
- 8) Reduce input power to a level that is safe for repositioning.
- 9) Select another row from Table 110 and repeat steps 2) to 8) until tests for all rows have been executed.
- 10) EVPC requests charging complete, and power reduces to zero.

101.1.5.3.2 Compatibility class A supply device test 2 test positions

Table 110 – Compatibility class A test 2 test positions

Test no.	XY_{test}	Z_{test}	V_{test}
1	00	N	350
2	N0	N	350
3	NP	N	350
4	0P	N	350
5	00	P	350
6	N0	P	350
7	NP	P	350
8	0P	P	350
9	00	N	406
10	N0	N	406
11	NP	N	406
12	0P	N	406
13	00	P	406
14	N0	P	406
15	NP	P	406
16	0P	P	406

Replace the EVPC to another Z class/WPT class and repeat until verification tests with all required EVPCs have been performed.

101.1.6 Compatibility class B supply device performance tests

101.1.6.1 General

When tested on the test bench, the performance test is set up with the supply device under test and all of the manufacturer specified EVPCs (one at a time) per 101.1.2.2.

The specified EVPCs and the compatibility class B supply device shall have a communication system that executes the control concept required by IEC 61980-2. The test conditions are managed by the test engineer.

The manufacturer or the test engineer shall create Table 111, equivalent to Table 110 for the alignment tolerance area (see 7.4.103) and the Z range (see 7.4.104) for each of the EVPCs specified. The voltage levels to be tested (V_{test}) are calculated for each EVPC as $V1_{\text{test}} = [V_{\text{min}} + 0,5 \times V_{\text{range}}]$ and $V2_{\text{test}} = [V_{\text{max}} - 0,1 \times V_{\text{range}}]$. See example in 101.1.6.3.2.

Under circumstances where symmetrical results across quadrants are reasonably expected, such as with a circular primary device and a circular secondary device, testing can be reduced to only one quadrant.

101.1.6.2 Compatibility class B supply device test 1

Test 1 is the initial test for each supply device using one EVPC of the highest WPT class.

- 1) The operating frequency is set to a fixed frequency specified by the manufacturer or determined by the test engineer with guidance from the manufacturer. The frequency shall be within the allowable frequency range of 79,0 kHz to 90,0 kHz. Record the frequency.
- 2) The input voltage to the supply device is set to nominal. Record the input voltage.
- 3) Set the X,Y,Z position to 0,0,0. Record the X,Y,Z position.
- 4) Set the output voltage to the midpoint of the output voltage range $[V_{\text{min}} + 0,5 \times V_{\text{range}}]$ as specified in 7.2.104.2.
- 5) The EVPC requests full power as specified by the manufacturer of the supply device. Monitor the ramp rate by starting a timer upon the request and stopping the timer upon reaching full power. Calculate and record the average ramp up rate.
- 6) When the system is in steady state at full power, record the input power and the output power, calculate and record the efficiency.
- 7) The test operator causes the EVPC to communicate an emergency in order to trigger an emergency stop power test. Monitor the emergency stop power timing by starting a timer upon the emergency signal and then at the point where the input power level creates a magnetic field strength at the surface of the supply device (or adjacent to it) that is equal to or lower than the EMF safe level. This level can be determined in terms of input power by prior testing. Record the time to achieve EMF safe level. Confirm that input power goes to zero.
- 8) The EVPC requests full power as specified by the manufacturer of the supply device. Once stable, interrupt the communication signal at the EVPC. Monitor and record the elapsed time for the supply device to acknowledge the loss of communication and the elapsed time until the magnetic field is equal to or lower than the EMF safe level.
- 9) Request zero power.
- 10) Set the output voltage to the minimum of the output voltage range (V_{min}) as specified in 7.2.104.2.
- 11) The EVPC requests full power as specified by the manufacturer of the supply device.
- 12) When the system is in steady state at full power, record the output voltage, the input power and the output power. Calculate and record the efficiency.
- 13) Request zero power.

- 14) Set the output voltage to the maximum of the output voltage range ($V_{\max}$) as specified in 7.2.104.2).
- 15) The EVPC requests full power as specified by the manufacturer of the supply device.
- 16) When the system is in steady state at full power, record the output voltage, the input power and the output power. Calculate and record the efficiency.
- 17) Request zero power.

End of test 1.

101.1.6.3 Compatibility class B supply device test 2

101.1.6.3.1 General

Test 2 is executed with the values from Table 111 established in 101.1.6.1. The order of the tests is determined by the test engineer, as long as a test for each row is executed.

- 1) Select a row from Table 111 to establish the test positions and output voltage to be used in steps 2) through 7).
- 2) The operating frequency is set to a fixed frequency specified by the manufacturer or determined by the test engineer with guidance from the manufacturer. The frequency shall be within the allowable frequency range of 79,0 kHz to 90,0 kHz. While it is required that it remain fixed for each charge session, it is permissible to change it between tests if necessary. Record the frequency.
- 3) The input voltage to the supply device is set to nominal. Record the input voltage.
- 4) The Z position is set to Z_{test} for the EVPC under test. Record Z_{test} .
- 5) The X,Y position is set to XY_{test} . Record XY_{test} .
- 6) Set the output voltage to V_{test} . Record V_{test} .
- 7) The EVPC requests full power as described by the manufacturer of the supply device. When the system is in steady state at full power, record the input power and the output power, calculate and record the efficiency.
- 8) Reduce input power to a level that is safe for repositioning.
- 9) Select another row from Table 111 and repeat steps 2) to 8) until tests for all rows have been executed.
- 10) EVPC requests charging complete, and power reduces to zero.

Replace the EVPC and repeat until verification tests with all required EVPCs have been performed.

101.1.6.3.2 Example of compatibility class B test 2 test positions

Example of a portion of Table 111, to be generated as specified in 101.1.6.1.

Table 111 – Example of compatibility class B supply device test 2 test positions

TEST no.	XY_{test}	Z_{test}	V_{test}
1	00	Min Z	$V1_{\text{test}}$
2	00	Min Z	$V2_{\text{test}}$
3	00	Max Z	$V1_{\text{test}}$
4	00	Max Z	$V2_{\text{test}}$
5	...	...	...
6	...	...	...
7	...	...	...

101.2 Tests for protection against heating effects of foreign objects

101.2.1 General

Foreign objects located in the area of operation (protection area 1) during power transfer may be subjected to heating effects due to exposure to the magnetic field. Heating effects include both high temperature that could result in burns or injury if contacted, or ignition hazards that could result in ignition of combustible materials due to heating of the metallic objects in contact with the materials. Foreign object detection systems are required to be used in WPT systems in order to detect these foreign objects when they are located in area 1 during power transfer, and subsequently, to shut down the power transfer function in order to mitigate the potential hazards associated with heating the foreign object. The requirements in 101.2 are intended to prove that the foreign object detection system will detect a foreign object when located in protection area 1 and will shut down the power transfer function prior to the foreign object exceeding touch temperature limits or igniting combustible materials.

As each WPT system and its foreign object detection system are different, the potential hazards associated with timely detection of foreign objects and proper shut down of the power transfer function may be different. A risk assessment is required to analyse and determine any potential hazards associated with the detection of foreign objects and the means to mitigate the risks associated with that detection. For the purposes of this document, the system shall be capable of detecting the specific objects as indicated in 101.2 and mitigating the hazards associated with these objects exceeding touch temperatures or causing ignition. The manufacturer may add additional test objects to the list based on the risk assessment associated with a given WPT system. If test objects are added, they shall be subjected to the same test method as the required objects.

101.2.2 Test bodies for touch hazard and ignition hazard

The listed test bodies are used to assess compliance of the WPT system with respect to the temperature limits specified in IEC 61980-1:2020, 11.6, applicable to foreign metallic objects located in the area of operation (protection area 1) and the ignition hazard as indicated in the test method.

The test objects specified in Table 112 represent the minimum test objects which are used to address touch hazards for this test. The test object specified in Table 113 represents the minimum test object which is used to address ignition hazards for this test. The test objects in Table 112 are deemed to have enough heat retention capacity to become a burn risk to a person coming in contact with one of these objects after the power transfer function is complete. The test objects in Table 113 are objects that are not deemed to have enough heat capacity to cause human burns but may reach temperature where they cause combustible material in contact with them to ignite.

NOTE The items which constitute the test bodies in 101.2.2 and the considerations for the test procedure have been filtered based on a study of probability and risk. Heating characteristic data has been part of the study. Compliance with these tests, based on the specifics of the systems being tested, will give a high confidence of safety. The confirmation test contained herein cannot guarantee safety under all possible conditions. Hence, each manufacturer needs to determine their own level of confidence and to adjust the test objects accordingly. There is also a signage recommendation (see 17.102) which serves to notify persons of the possible hazard.

Table 112 – Test bodies for touch hazard

Brief object description	Size	Material (composition)	Test position
Aluminium foil	60 mm to 80 mm diameter 0,01 mm to 0,03 mm thick	Aluminium alloy	Flat on surface
Steel bar	100 mm long 70 mm wide 10 mm high	Uncoated steel	Flat on the 100 mm x 70 mm surface
Nail	75 mm to 100 mm long 3 mm to 4 mm diameter	Uncoated steel	Flat
Coin	5 cent Euro coin or equivalent 21,25 mm diameter 1,67 mm thick	Steel: 94,35 % Cu 5,65 %	Flat

Table 113 – Test objects for ignition risk test

Brief object description	Size	Material (composition)	Test position
Paper clip attached to stack of paper	23 mm to 29 mm long 0,9 mm to 1,1 mm wire 5 sheets: 75 g to 100 g per square meter (20 lb to 24 lb equivalent), 100 mm x 100 mm	Uncoated steel	Paper clip is the part to be centred on identified positions

101.2.3 Test area specification

As each WPT system is different, and each implementation of foreign object detection is different, the test shall be performed based on specifications from the manufacturer in relation to alignment conditions and physical location of the test object. These specific parameters shall address the alignment condition and test object location that will result in the maximum heating effect (location where the field strength is highest under specific conditions of alignment) and the alignment condition and test object location where the foreign object detection is least effective. That information shall be specified by the manufacturer when presenting test samples based on the following.

- The manufacturer shall specify the location on the surface of the primary device that has the highest field strength and under what conditions of alignment that this highest field strength exists. Additionally, the manufacturer shall specify the orientation of the field at this location. Worst case (most rapid) heating will occur when the foreign object is located at that location with its major dimension oriented along the major field component direction. This location and orientation direction shall be marked on the surface of the primary device. This is test point 1.