INTERNATIONAL STANDARD

ISO 18246

Second edition
2023-01

Electrically propelled mopeds and motorcycles — Safety requirements for conductive connection to an external electric power supply

Cyclomoteurs et motocycles à propulsion électrique — Exigences de sécurité relatives au couplage conductif à une borne d'alimentation électrique externe

Reference number
ISO 18246:2023(E)

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Published in Switzerland

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Foreword

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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 of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 38, *Motorcycles and mopeds,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 301, *Electrically propelled road vehicles,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 18246:2015), which has been technically revised.

The main changes are as follows:

— terms and definitions have been updated;

— requirements for protection against electric shock (Clause 7) have been rewritten;

— descriptions for additional requirements and test procedure (Clause 9) have been simplified;

— requirements for the specific DC charging systems have been described in the Annexes (Annex B for IEC 61851-25 and Annex C for IEC TS 61851-3 series).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document prescribes basic safety requirements for electrically propelled mopeds and motorcycles, which are called electrically propelled vehicles (EVs), for simplicity, while connected to an external electric power supply. The safety requirements for off-board appliances/equipment are not described in this document.[1)]

This document does not standardize specific charging method in the body text. The requirements for specific DC charging systems are described in Annex B and Annex C.

Moped and motorcycle are defined in ISO 3833:1977, 3.4 and 3.5.

1) See IEC 60335-2-29, IEC 61851-25, and IEC TS 61851-3 series.

Electrically propelled mopeds and motorcycles — Safety requirements for conductive connection to an external electric power supply

1 Scope

This document specifies safety requirements for conductive connection of electrically propelled mopeds and motorcycles (referred to as the EVs) to external electric circuits.

NOTE 1 External electric circuits include external electric power supplies and external electric loads.

It does not provide comprehensive safety information for manufacturing, maintenance and repair personnel.

It applies only to on-board charging systems between the plug or vehicle inlet and RESS circuits.

NOTE 2 The requirements when not connected to external electric circuits are specified in the ISO 13063 series.

Requirements for bidirectional energy transfer DC to AC are under consideration and are not part of this document.

NOTE 3 The safety requirements for DC EV supply equipment where protection relies on electrical separation are specified in IEC 61851-25.

NOTE 4 The safety requirements for DC EV supply equipment where protection relies on double or reinforced insulation are specified in IEC TS 61851-3-1 and IEC TS 61851-3-2.

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 6469-3:2021, *Electrically propelled road vehicles — Safety specifications — Part 3: Electrical safety*

ISO 7010, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 13063-3:2022, *Electrically propelled mopeds and motorcycles — Safety specifications — Part 3: Electrical safety*

ISO 17409:2020, *Electrically propelled road vehicles — Conductive power transfer — Safety requirements*

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

IEC 60664 SER, *Insulation coordination for equipment within low-voltage systems — All Parts*

IEC 61140:2016, *Protection against electric shock — Common aspects for installation and equipment*

IEC 61851-1:2017, *Electric vehicle conductive charging system — Part 1: General requirements*

IEC 61851-23, *Electric vehicle conductive charging system — Part 23: DC electric vehicle charging station*

IEC 61851-25:2020, *Electric vehicle conductive charging system — Part 25: DC EV supply equipment where protection relies on electrical separation*

IEC/TS 61851-3-1:—,[2] *Electric Vehicles conductive charging system — Part 3-1: DC EV supply equipment where protection relies on double or reinforced insulation – General rules and requirements for stationary equipment*

IEC 62196-2, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories*

IEC/TS 62196-4, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 4: Dimensional compatibility and interchangeability requirements for d.c. pin and contact-tube accessories for class II or class III applications*

IEC 62196-6, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 6: Dimensional compatibility requirements for DC pin and contact-tube vehicle couplers for DC EV supply equipment where protection relies on electrical separation*

3 Terms and definitions

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

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

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

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

3.1 General

3.1.1
electrically propelled vehicle
EV
vehicle with one or more electric drive(s) for vehicle propulsion

Note 1 to entry: In the context of this document, the term electrically propelled vehicle (EV) includes only moped or motorcycle.

[SOURCE: ISO 13063-3:2022, 3.14, modified — Terminological entry "EV" and note 1 to entry are added.]

3.1.2
rechargeable energy storage system
RESS
rechargeable system that stores energy for delivery of electric energy for the electric drive

EXAMPLE Battery, capacitor, flywheel.

[SOURCE: ISO 13063-3:2022, 3.23]

3.1.3
removable RESS
RESS (3.1.2) that can be moved/removed from an *EV* (3.1.1) by hand (portable RESS) or with the assistance of an installation/device (mobile RESS)

[SOURCE: EN 50604-1:2016 +A1:2021, 3.18]

3.1.4
indoor use
intended for operation under normal ambient conditions in a building

[SOURCE: IEC 61851-1:2017, 3.6.1]

2) Under preparation. Stage at the time of publication: IEC 69/845/DTS:2022.

3.1.5
outdoor use
capable of operating under specific range of outdoor conditions

[SOURCE: IEC 61851-1:2017, 3.6.2]

3.1.6
maximum working voltage
highest value of AC voltage (rms) or of DC voltage that can occur in an electric system under any normal operating conditions according to the manufacturers' specifications, disregarding transients and ripple

[SOURCE: ISO 13063-3:2022, 3.20]

3.1.7
voltage class A
classification of an electric component or circuit, if its *maximum working voltage* (3.1.6) is ≤30 V a.c. or ≤60 V d.c., respectively

Note 1 to entry: The values 60 V d.c. and 30 V a.c. are selected taking into account humid weather conditions.

3.1.8
voltage class B
classification of an electric component or circuit, if its *maximum working voltage* (3.1.6) is >30 and ≤1 000 V a.c. or >60 and ≤1 500 V d.c., respectively

Note 1 to entry: The values 60 V d.c. and 30 V a.c. are selected taking into account humid weather conditions.

3.1.9
electric chassis
conductive parts of a vehicle that are electrically connected and whose potential is taken as reference

[SOURCE: ISO 13063-3:2022, 3.11]

3.1.10
accessible part
part which can be touched by means of the standard test finger

[SOURCE: IEV 442-01-15, modified — "a" is deleted.]

3.1.11
degree of protection
protection provided by an enclosure against access, foreign objects and/or water and verified by standardized test methods

EXAMPLE IPXXB (by test finger), IPXXC (by test rod), or IPXXD test wire (by test wire), in accordance with ISO 20653

[SOURCE: ISO 20653:2013, 3.2, modified — EXAMPLES are added.]

3.1.12
single fault condition
condition in which one means for protection against electric shock is defective or one fault is present which could cause a hazard

Note 1 to entry: If a single fault condition results in one or more other fault conditions, all are considered as one single fault condition.

[SOURCE: IEC 61140:2016, 3.1.4]

3.2 Charging

3.2.1
EV charging system
complete system including the *EV supply equipment* (3.2.5) and the EV functions that are required to supply electric energy to an *EV* (3.1.1) for the purpose of charging

[SOURCE: IEC 61851-1:2017, 3.1.4]

3.2.2
on-board charging system
on-board sections of *EV charging system* (3.2.1), which may have dedicated control functions used for the connection of the vehicle to an external electric circuit

3.2.3
on-board charging equipment
equipment or a combination of equipment in the *on-board charging system* (3.2.2)

3.2.4
external electric power supply
electric power source that is not part of the vehicle for supplying electric energy to an *EV* (3.1.1) using an *EV supply equipment* (3.2.5)

[SOURCE: ISO 17409:2020, 3.28]

3.2.5
EV supply equipment
equipment or a combination of equipment providing dedicated functions to supply electric energy from a fixed electrical installation or supply network to an *EV* (3.1.1) for the purpose of charging

[SOURCE: ISO 17409:2020, 3.25, modified — EXAMPLE 1 and 2 are not cited.]

3.2.6
charger
power converter that performs the necessary functions for charging a battery

3.2.7
charger assembly
power converter that performs the necessary functions for charging a battery, including cables

3.2.8
vehicle power supply circuit
voltage class B (3.1.8) electric circuit which includes all parts that are galvanically connected to the vehicle inlet (case B, case C) or the plug (case A) and that is operational when connected to an *external electric power supply* (3.2.4)

Note 1 to entry: Case A, case B and case C are defined in IEC 61851-1.

3.2.9
primary circuit
circuit in the *charger* (3.2.6) intended to be galvanically connected to a supply network (mains)

3.2.10
secondary circuit
circuit that has no direct connection to a *primary circuit* (3.2.9) and derives its power from a transformer, converter or equivalent isolation device

[SOURCE: IEC 61851-23:2014, 3.112]

3.2.11
RESS circuit
electric circuit which includes all live parts that are galvanically connected to the *secondary circuits* (3.2.10) of the *charger* (3.2.6) and charging circuits of *RESS* (3.1.2), excluding propulsion circuits

3.2.12
control pilot circuit
circuit designed for the transmission of signals or communication between the *EV* (3.1.1) and the *EV supply equipment* (3.2.5)

[SOURCE: IEC 61851-1:2017, 3.3.2, modified — Note 1 to entry was deleted.]

3.3 Connection

3.3.1
AC connection
connection at a vehicle inlet or plug, with an external AC power supply

3.3.2
DC connection
connection at a vehicle inlet or plug, with an external DC power supply

3.3.3
charging cable assembly
assembly consisting of flexible cable or cord fitted with a plug and/or a vehicle connector, that is used to establish the connection between the *EV* (3.1.1) and the supply network or an EV charging station

Note 1 to entry: A cable assembly can be detachable or be a part of the EV or the EV charging station.

Note 2 to entry: A cable assembly can include one or more cables, with or without a fixed jacket, which can be in a flexible tube, conduit or wire way.

3.3.4
socket-outlet
accessory having socket-contacts designed to engage with the pins of a plug and having terminals for the connection of cables or codes

[SOURCE: IEC 61851-1:2017, 3.5.10]

3.3.5
plug
accessory having pins designed to engage with the contacts of a *socket-outlet* (3.3.4)

Note 1 to entry: It also incorporate means for the electrical connection and mechanical retention of flexible cables or codes.

[SOURCE: IEV 442-03-01, modified — The second part of sentence is moved to Note 1 to entry.]

3.3.6
vehicle coupler
means enabling the connection and disconnection at will, of a flexible cable to an *EV* (3.1.1)

Note 1 to entry: It consists of two parts: a vehicle connector and a vehicle inlet.

3.3.7
vehicle connector
part integral with, or intended to be attached to, one flexible cable

[SOURCE: IEC 62196-1:2022, 3.56 modified — Terminological entry "electric vehicle connector" is not cited.]

3.3.8
vehicle inlet
part incorporated in, or fixed to, the *EV* (3.1.1)

[SOURCE: IEC 62196-1:2022, 3.57 modified — Terminological entry "electric vehicle inlet" is not cited, and "electric vehicle" is replaced with "EV".]

3.3.9
RESS coupler
means enabling the connection and disconnection of *RESS* (3.1.2) to a flexible cable, an *EV* (3.1.1) or a *charger assembly* (3.2.7)

Note 1 to entry: It consists of two parts: a RESS connector and a RESS inlet.

3.3.10
RESS connector
part of a *RESS coupler* (3.3.9) integral with, or intended to be attached to, a flexible cable, an *EV* (3.1.1) or a *charger assembly* (3.2.7)

3.3.11
RESS inlet
part of a *RESS coupler* (3.3.9) incorporated in, or fixed to, *RESS* (3.1.2)

3.3.12
terminal
conductive part provided for the connection of a conductor to an accessory

[SOURCE: IEC 62196-1:2022, 3.50]

3.4 Electrical safety

3.4.1
live part
conductor or conductive part intended to be energized in normal use, but by convention, not the *electric chassis* (3.1.9)

[SOURCE: ISO 6469-1:2019, 3.16]

3.4.2
hazardous-live-part
live part (3.4.1) which, under certain conditions, can give a harmful electric shock

[SOURCE: IEV 826–12–13]

3.4.3
basic protection
protection against electric shock under fault-free conditions

[SOURCE: IEC 61140:2016, 3.1.1]

3.4.4
fault protection
protection against electric shock under *single-fault conditions* (3.1.12)

[SOURCE: IEC 61140:2016, 3.1.2]

3.4.5
additional protection
protection against electric shock in addition to *basic protection* (3.4.3) and/or *fault protection* (3.4.4)

[SOURCE: IEC 61140:2016, 3.1.3]

3.4.6
basic insulation
insulation of *hazardous-live-parts* (3.4.2) which provides *basic protection* (3.4.3)

Note 1 to entry: This concept does not apply to insulation used exclusively for functional purposes.

[SOURCE: IEV 195-06-06]

3.4.7
supplementary insulation
independent insulation applied in addition to *basic insulation* (3.4.6), for *fault protection* (3.4.4)

[SOURCE: IEV 195-06-07]

3.4.8
double insulation
insulation comprising both *basic insulation* (3.4.6) and *supplementary insulation* (3.4.7)

[SOURCE: IEV 195-06-08]

3.4.9
reinforced insulation
insulation of *hazardous-live-parts* (3.4.2) which provides a *degree of protection* (3.1.11) against electric shock equivalent to *double insulation* (3.4.8)

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

[SOURCE: IEV 195-06-09]

3.4.10
galvanic separation
prevention of electric conduction between two electric circuits intended to exchange power and/or signals

Note 1 to entry: Galvanic separation can be provided e.g. by an isolating transformer or an opto-coupler.

[SOURCE: IEV 151-12-26]

3.4.11
simple separation
separation between electric circuits or between an electric circuit and local earth by means of *basic insulation* (3.4.6)

[SOURCE: IEC 61140:2016, 3.23]

3.4.12
protective separation
electrically protective separation
separation of one electric circuit from another by means of:

— *double insulation* (3.4.8); or

— *basic insulation* (3.4.6) and electrically protective screening (shielding); or

— *reinforced insulation* (3.4.9)

[SOURCE: IEC 61140:2016, 3.24]

3.4.13
exposed conductive part
conductive part of equipment which can be touched and which is not normally live, but which can become live when *basic insulation* (3.4.6) fails

[SOURCE: ISO 17409:2020, 3.26]

3.4.14
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

[SOURCE: IEV 195-01-10]

3.4.15
equipotential bonding terminal
terminal (3.3.12) provided on equipment or on a device and intended for the electric connection with the equipotential bonding system

[SOURCE: IEV 195-02-32]

3.4.16
protective conductor
conductor provided for the purposes of safety, for example protection against electric shock

[SOURCE: IEC 61140:2016, 3.16.4]

3.4.17
PE conductor
protective conductor (3.4.16) provided for protective earthing

[SOURCE: IEC 61140:2016, 3.16.5]

3.4.18
residual current device
RCD
mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

Note 1 to entry: A residual current device can be a combination of various separate elements designed to detect and evaluate the residual current and to make and break current.

[SOURCE: IEV 442-05-02]

3.4.19
isolation resistance monitoring system
system that monitors the isolation resistance between *live parts* (3.4.1) and the *electric chassis* (3.1.9) or *exposed conductive parts* (3.4.13)Table 1 provides an alphabetical cross-reference listing of terms.

Table 1 — Alphabetical list of terms

Term	Term number	Term	Term number
AC connection	3.3.1	on-board charging system	3.2.2
accessible part	3.1.10	outdoor use	3.1.5
additional protection	3.4.5	PE conductor	3.4.17
basic insulation	3.4.6	plug	3.3.5
basic protection	3.4.3	primary circuit	3.2.9
charger	3.2.6	protective conductor	3.4.16
charger assembly	3.2.7	protective separation	3.4.12
charging cable assembly	3.3.3	RCD	3.4.18
control pilot circuit	3.2.12	rechargeable energy storage system	3.1.2
DC connection	3.3.2	reinforced insulation	3.4.9
degree of protection	3.1.11	removable RESS	3.1.3
double insulation	3.4.8	residual current device	3.4.18
electric chassis	3.1.9	RESS	3.1.2
electrically propelled vehicle	3.1.1	RESS circuit	3.2.11
electrically protective separation	3.4.12	RESS connector	3.3.10
equipotential bonding	3.4.14	RESS coupler	3.3.9
equipotential bonding terminal	3.4.15	RESS inlet	3.3.11
EV	3.1.1	secondary circuit	3.2.10
EV charging system	3.2.1	simple separation	3.4.11
EV supply equipment	3.2.5	single fault condition	3.1.12
exposed conductive part	3.4.13	socket-outlet	3.3.4
external electric power supply	3.2.4	supplementary insulation	3.4.7
fault protection	3.4.4	terminal	3.3.12
galvanic separation	3.4.10	vehicle connector	3.3.7
hazardous-live-part	3.4.2	vehicle coupler	3.3.6
indoor use	3.1.4	vehicle inlet	3.3.8
isolation resistance monitoring system	3.4.19	vehicle power supply circuit	3.2.8
live part	3.4.1	voltage class A	3.1.7
maximum working voltage	3.1.6	voltage class B	3.1.8
on-board charging equipment	3.2.3		

4 Environmental and operational conditions

The requirements given in this document shall be met across the range of environmental and operational conditions for which the EVs are designed to operate when connected to an external electric circuit (e.g. external electric power supply), as specified by the vehicle manufacturer.

NOTE 1 See ISO 16750, ISO/PAS 19295, ISO 21498 and ISO 19453 for guidance.

The requirements specified in this document shall be fulfilled under all relevant energy levels (e.g. SOC of RESS) of the electric power sources of the EV.

The requirements given in this document shall be met across the range of environmental and operational conditions for which the EVs and the RESS including removable RESS are designed to be charged, as specified by the vehicle or RESS manufacturer.

NOTE 2 The safety requirements of the batteries, including removable batteries, are described in the battery standards, such as ISO 18243:2017 and EN 50604-1:2016+A1:2021.

5 General requirements

The on-board charging system shall be designed in order to:

— be operated safely and properly in normal use; and

— protect the rider and/or surroundings against electric shock even under single fault condition.

The first failure in the EV supply equipment and simultaneously occurring first failure in the EV, if they are connected to each other, is not to be considered as double failure, protection against electric shock shall be implemented independently.

Requirements for the vehicle, in case of connection to the off-board charging systems according to IEC 61851-25, are described in Annex B and shall be followed.

Conformance is checked with the relevant requirements and tests specified in this document.

6 Connection between the plug or vehicle couplers and RESS of the vehicle

6.1 General

6.1.1 Connections among charger, RESS, and vehicle

In the most fundamental sense of charging, there are three functional portions. The first is the supply network (mains). The second is the charger assembly that consists of charger and cable assembly. The third is the RESS, which may be incorporated onto the vehicle.

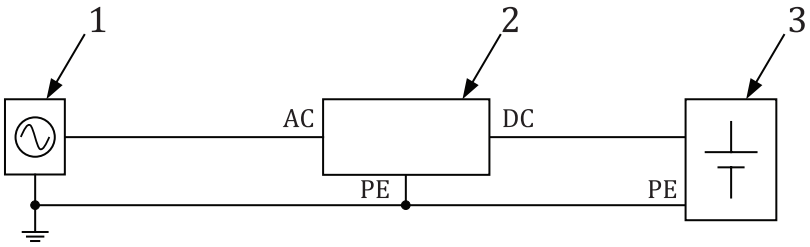
There are four ways in conductive charging systems regarding the connection to the earth by PE conductor. They are as follows.

a) Connection to the earth: it consists of the charger assembly and the vehicle/RESS, both of them connected to the earth for fault protection. The requirements are specified in 6.1.3.2.

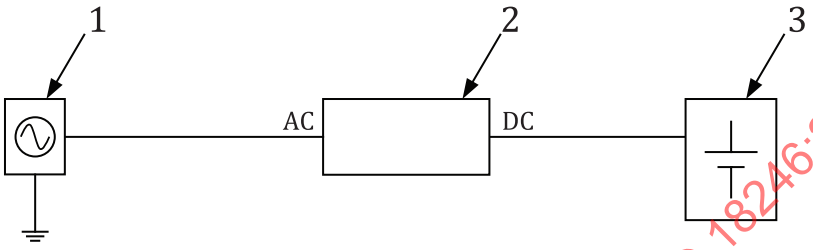
b) No connection to the earth: it consists of the charger assembly and the vehicle/RESS, neither of them connected to the earth. The requirements are specified in 6.1.3.3.

c) Separate connection to the earth: it consists of the charger assembly unconnected to the earth and the vehicle/RESS connected to the earth for fault protection. The requirements are specified in 6.1.3.4.

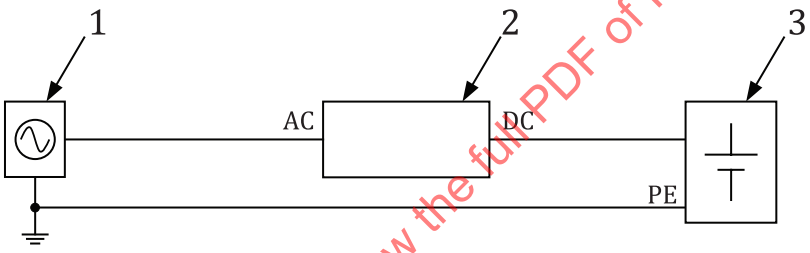
d) Partial connection to the earth: it consists of the charger assembly connected to the earth for fault protection and the vehicle/RESS unconnected to the earth. The requirements are specified in 6.1.3.5.



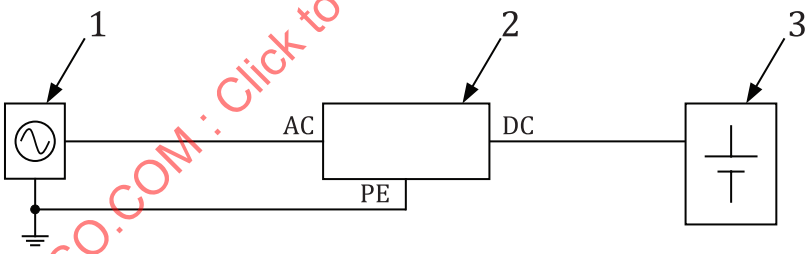
a) Connection to the earth



b) No connection to the earth



c) Separate connection to the earth



d) Partial connection to the earth

Key

1 AC supply network (mains)

2 charger

3 vehicle or removable RESS

Figure 1 — Construction of the connection to the earth

Figure 1 shows TN power supply systems. Other configurations including TT power supply systems also exist.

An EV can be connected to an EV supply equipment or external electric circuit (e.g. external electric power supply) by Case A, B or C according to IEC 61851-1.

6.1.2 General requirements for connection

6.1.2.1 Connection and disconnection

The manufacturers shall use a coupler/plug that satisfies the following requirements.

— It shall not be possible to engage couplers/plug with different voltage rating or current rating.

— Vehicle couplers and RESS couplers as the parts of the on-board charging system shall not be compatible. In case of charging type B or C described in Annex A, vehicle connectors and RESS connectors may be compatible in accordance with vehicle manufacturer's guidance or relevant standards for connection.

— If removable RESS is used, the vehicle coupler and the RESS coupler can be the same.

When the vehicle connector is connected to charge the vehicle and/or disconnected, the means preventing access to the live parts from any usual direction shall be provided.

Connection or disconnection of the vehicle coupler shall not cause the overturn of the vehicle in the normal operating conditions.

6.1.2.2 Wiring

Any connections integral to the on-board charging system shall not cause overheating of the pins and/or wires or impose undue strain on couplers/plugs.

Wiring and cable that may coming to contact shall be rated for the highest voltage present.

Wire ways shall be smooth and free from sharp edges. Separate parts which can move during charging relative to each other shall not cause undue stress to electrical connections and internal conductors, including those providing equipotential bonding.

Even if the movable part of the on-board charging equipment is moved backwards and forwards and the conductor is flexed through the largest angle permitted by its construction, no damage shall occur to the wiring.

If an open coil spring or cord guards are used, it shall be correctly installed and insulated. Flexible metallic tubes shall not cause damage to the insulation of the conductors contained within them.

Inlet openings and/or charging cable assemblies entries shall allow the introduction of the conduit or the sheath of the wires and/or cable so as to afford complete mechanical protection.

Conduit entries, charging cable assemblies entries and knockouts shall be constructed or located so that the introduction of the conduit or cable does not reduce creepage distances or clearances with the values specified in 9.5.

Conduit entries, charging cable assemblies entries and knockouts shall be constructed or located so that the introduction of the conduit or cable does not reduce the protection measures adopted by the manufacturer.

Conformance is checked by inspection.

6.1.3 Requirements for connection or no connection to the earth

6.1.3.1 Requirements for combination

The on-board charging system shall be one of the combinations specified in Table 2 or Table 3.

NOTE Refer to A.2 for the parts included in charging system.

The insulation requirements described in Table 2 and Table 3 show the minimum requirements for each combination, and samples of circuit diagram for each case are illustrated in Figure 2 and Figure 3.

The vehicle inlet shall not be compatible with connectors which are not intended to be accommodated.

Table 2 — Allowable combination of charger and vehicle (the case of charging type A)

On-board chargers (fixed on vehicle)			Vehicles			The construction of the connection to the earth[d]
Insulation between the enclosure and primary circuits[c]	Earthing of exposed conductive parts of primary circuits	Separation between the primary circuits and secondary circuits	Voltage class of RESS circuits	Insulation between the accessible parts and RESS circuits	Earthing of exposed conductive parts	
Basic[a, b]	X	No galvanic separation	A/B	Basic[a, b]	X	Refer to a
			A/B	Double or reinforced[a]	—	Refer to d
		Simple separation	A/B	Basic[b]	X	Refer to a
			A/B	Double or reinforced	—	Refer to d
		Protective separation	A	—	—	Refer to d
			A/B	Basic[b]	—	Refer to d
			A/B	Double or reinforced	—	Refer to d
Double or reinforced	—	No galvanic separation	A/B	Basic[a, b]	X	Refer to c
			A/B	Double or reinforced[a]	—	Refer to b
		Simple separation	A/B	Basic[b]	X	Refer to c
			A/B	Double or reinforced	—	Refer to b
		Protective separation	A	—	—	Refer to b
			A/B	Basic[b]	—	Refer to b
			A/B	Double or reinforced	—	Refer to b

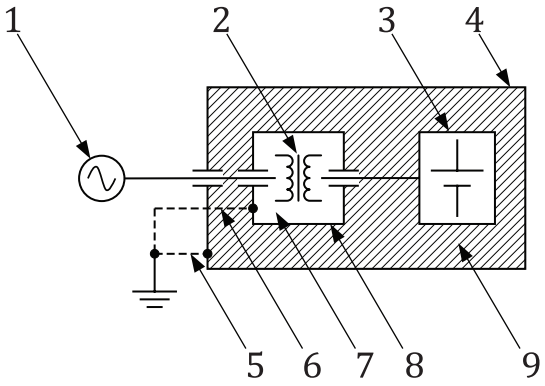
Potential equalization is required for the exposed conductive parts of voltage class B circuits of the vehicle in ISO 13063-3:2022, 7.3.1.

[a] ISO 13063-3 does not prohibit users from accessing to the voltage class A live parts of the vehicle.

[b] According to ISO 13063-3, an additional protection shall be required for the vehicle with the voltage class B component with basic insulation as a protective measure against electrical shock, in case that enough insulation is not ensured under single fault condition.

[c] The enclosure of chargers can be constructed of the exterior portion (e.g. enclosure) of the vehicle and also a part of the enclosure of a charger may be exposed.

[d] Refer to 6.1.1.



Key

1 AC supply network (mains)
2 separation between the primary circuit and secondary circuit of on-board chargers
3 RESS
4 accessible parts of the vehicle
5 earth for protection of the vehicle
6 earth for protection of on-board chargers
7 insulation between the enclosure and primary circuits of on-board chargers
8 enclosure of on-board chargers (fixed)
9 insulation between the accessible parts and RESS circuits of the vehicle

Figure 2 — Sample of circuit diagram (the case of charging type A)

Table 3 — Allowable combination of charger and vehicle (the case of charging type B) or removable RESS (the case of charging type C)

Off-board DC charger[c]	Vehicle or removable RESS			The construction of the connection to the earth[d]
Separation between AC supply network (mains) and the vehicle or detachable RESS[c]	Voltage class of RESS circuits	Grade of insulation between the accessible parts and RESS circuits	Earthing of exposed conductive parts	
Simple separation	A/B	Basic[b]	X	Refer to a or c
	A/B	Double or reinforced	—	Refer to b or d
Protective separation	A	—	—	Refer to b or d
	A/B	Basic[b]	—	Refer to b or d
	A/B	Double or reinforced	—	Refer to b or d

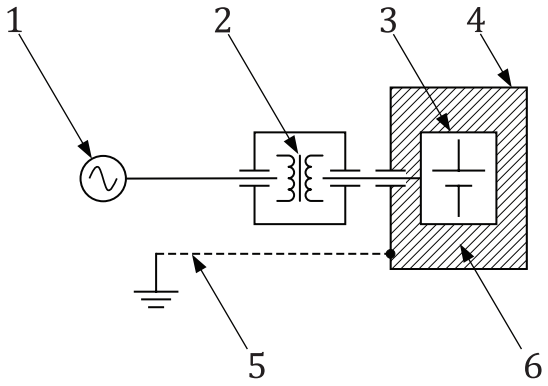
Potential equalization is required for the exposed conductive parts of voltage class B circuits of the vehicle in ISO 13063-3:2022, 7.3.1.

[a] ISO 13063-3 does not prohibit users from accessing to the voltage class A live parts of the vehicle.

[b] According to ISO 13063-3, an additional protection shall be required for the vehicle with the voltage class B component with basic insulation as a protective measure against electrical shock, in case that enough insulation is not ensured under single fault condition.

[c] The grades showed in these columns are conditions of off-board chargers, which are necessary to provide requirements for a vehicle.

[d] Refer to 6.1.1.



Key

1 AC supply network (mains)
2 separation between the AC supply network (mains) and the vehicle
3 RESS
4 accessible parts of the vehicle
5 earth for protection of the vehicle
6 insulation between the accessible parts and RESS circuit of the vehicle

Figure 3 — Sample of circuit diagram (the case of charging type B)

6.1.3.2 Requirements of the "connection to the earth"

The construction of the connection to the earth is specified in 6.1.1.

In the case of charging type A (the charger is on boarded), the following conditions shall be satisfied in order to make up this connection:

— no galvanic separation or simple separation between the primary circuits and secondary circuits of the on-board charger;

— the insulation of on-board chargers between the enclosure and primary circuits being basic insulation;

— the insulation of vehicle between the accessible parts and RESS circuits being basic insulation;

— earthing of enclosure of on-board chargers;

— earthing of exposed conductive parts of vehicle.

In the case of charging type B or C, the following conditions shall be satisfied in order to make up this connection:

— simple separation between AC supply network (mains) and vehicle and/or removable RESS;

— the insulation of vehicle and/or removable RESS between the accessible parts and RESS circuits being basic insulation;

— earthing of exposed conductive parts of vehicle and/or removable RESS.

The protection measures shall meet the requirements as described in 7.2 and 7.3 and conformance shall be tested according to Clause 9.

For this connection, the EV can be connected to an EV supply equipment according to IEC 61851-1 and/or IEC 61851-23. If the EV is connected to EV supply equipment according to IEC 61851-1 or IEC 61851-23, ISO 17409 shall be applied.

6.1.3.3 Requirements of "no connection to the earth"

The construction of the connection is specified in 6.1.1.

In the case of charging type A, the following conditions shall be satisfied in order to make up this connection:

— no galvanic separation or simple separation between the primary circuits and secondary circuits;

— the insulation of on-board chargers between the enclosure and primary circuits being double or reinforced insulation;

— the insulation of vehicle between the accessible parts and RESS circuits being double or reinforced insulation;

or

— protective separation between the primary circuits and secondary circuits;

— the insulation of on-board chargers between the enclosure and primary circuits being double or reinforced insulation;

— the insulation of vehicle between the accessible parts and RESS circuits being at least basic insulation;

or

— protective separation between the primary circuits and secondary circuits;

— the insulation of on-board chargers between the enclosure and primary circuits being double or reinforced insulation;

— voltage class of RESS circuits being A.

In the case of charging type B or C, the following conditions shall be satisfied in order to make up this connection:

— simple separation between AC supply network (mains) and vehicle and/or removable RESS;

— the insulation of vehicle and/or removable RESS between the accessible parts and RESS circuits being double or reinforced insulation;

or

— protective separation between AC supply network (mains) and vehicle and/or removable RESS;

— the insulation of vehicle and/or removable RESS between the accessible parts and RESS circuits being at least basic insulation;

or

— protective separation between AC supply network (mains) and vehicle and/or removable RESS;

— voltage class of RESS circuits being A.

The protection measures shall meet the requirements as described in 7.2 and 7.3 and conformance shall be tested according to Clause 9.

For this connection, the EV can be connected to an EV supply equipment according to IEC TS 61851-3 series. If the EV is connected to EV supply equipment according to IEC TS 61851-3 series, this document is applicable. (See Annex C.)

6.1.3.4 Requirements of a "separate connection to the earth"

The construction of the connection to the earth is specified in 6.1.1.

In the case of charging type A, the following conditions shall be satisfied in order to make up this connection:

— no galvanic separation or simple separation between the primary circuits and secondary circuits;

— the insulation of on-board chargers between the enclosure and primary circuits being double or reinforced insulation;

— the insulation of vehicle between the accessible parts and RESS circuits being basic insulation;

— earthing of exposed conductive parts of vehicle.

In the case of charging type B or C, the following conditions shall be satisfied in order to make up this connection:

— simple separation between AC supply network (mains) and vehicle and/or removable RESS;

— the insulation of vehicle and/or removable RESS between the accessible parts and RESS circuits being basic insulation;

— earthing of exposed conductive parts of vehicle and/or removable RESS.

NOTE The requirements described in "connection to the earth" are applicable if the off-board charger is equipped with earthing.

When the equipotential bonding terminal of RESS/vehicle is connected to the protective conductor, the PE conductor connected between the AC supply network (mains) and RESS and/or vehicle may be bypassed through the off-board charger assembly.

The protection measures shall meet the requirements as described in 7.2 and 7.3 and conformance shall be tested according to Clause 9.

6.1.3.5 Requirements of "partial connection to the earth"

The construction of the connection to the earth is specified in 6.1.1.

In the case of charging type A, the following conditions shall be satisfied in order to make up this connection:

— no galvanic separation or simple separation between the primary circuits and secondary circuits;

— the insulation of on-board chargers between the enclosure and primary circuits being basic insulation;

— the insulation of vehicle between the accessible parts and RESS circuits being double or reinforced insulation;

— earthing for enclosure of on-board chargers;

or

— protective separation between the primary circuits and secondary circuits;

— the insulation of on-board chargers between the enclosure and primary circuits being basic insulation;

— the insulation of vehicle between the accessible parts and RESS circuits being at least basic insulation;

— earthing for enclosure of on-board chargers;

or

— protective separation between the primary circuits and secondary circuits;

— the insulation of on-board chargers between the enclosure and primary circuits being basic insulation;

— voltage class of RESS circuits being A;

— earthing for enclosure of on-board chargers.

In the case of charging type B or C, the following conditions shall be satisfied in order to make up this connection:

— simple separation between AC supply network (mains) and vehicle and/or removable RESS;

— the insulation of vehicle and/or removable RESS between the accessible parts and RESS circuits being double or reinforced insulation;

or

— protective separation between AC supply network (mains) and vehicle and/or removable RESS;

— the insulation of vehicle and/or removable RESS between the accessible parts and RESS circuits being at least basic insulation;

or

— protective separation between AC supply network (mains) and vehicle and/or removable RESS;

— voltage class of RESS circuits being A.

NOTE 1 The requirements described in 6.1.3.3 are applicable if the off-board charger is not equipped with earthing.

The protection measures shall meet the requirements as described in 7.2 and 7.3 and conformance shall be tested according to Clause 9.

NOTE 2 When the off-board charger assembly is connected to the earth, the RCD or monitoring system to detect leaking current to the earth can be installed onto the connection between the AC supply network (mains) and RESS of the vehicle.

For this connection, the EV can be connected to an EV supply equipment according to IEC 61851-25:2020. If the EV is connected to EV supply equipment according to IEC 61851-25:2020, this document is applicable. (See Annex B.)

6.1.4 Specific requirements for the vehicle inlet

The requirements of the vehicle inlet or RESS inlet are specified by the vehicle manufacturer.

The vehicle inlet intended to be connected with EV supply equipment, which is provided by the IEC 61851 series, shall comply with IEC 62196 series.

When equipped with a vehicle inlet that is not intended for disconnection under load, the vehicle shall provide an appropriate latching device or retaining means.

For vehicles connected to EV supply equipment in accordance with IEC 61851-1, plug or vehicle inlet shall be in accordance with IEC 62196-2.

For vehicles connected to DC EV supply equipment in accordance with IEC 61851-25, the vehicle shall be in accordance with IEC 62196-6.

For vehicles connected to DC EV supply equipment in accordance with IEC TS 61851-3 series, plug or vehicle inlet shall be in accordance with IEC TS 62196-4.

6.1.5 Vehicle behaviour during charging

If the plug is connected to the external electric power supply, vehicle movement by its own propulsion system shall be impossible.

For a vehicle with a permanently attached charging cable, this requirement is not applicable if using the cable to charge the vehicle prevents the use of the vehicle (e.g. seat cannot be closed, the cable position does not allow the rider to sit in or step into the vehicle).

In case that the device equipped on the vehicle provides the vehicle with maintaining standstill, the propulsion motor may activate even if the plug is connected to the external electric power supply.

If the vehicle is disconnected from the external electric power supply, unintentional vehicle movement by its own propulsion system shall not be induced.

6.2 AC connection

6.2.1 Requirements for the connection to AC supply network (mains)

There shall be only one means of connecting the charger to an external power supply.

Conformance is checked by inspection.

In the case of charging type A described in Annex A, the connecting parts of charging cable assembly that comply with IEC 60884 shall not exceed the following ranges for either indoor use or outdoor use:

— alternate rated working voltage 440 V;

— alternate rated current 32 A.

If pre-soldered flexible conductors are used for an AC connection with screw-type terminals, care shall be taken that the pre-soldered area shall be outside of the clamp area when connected as for normal use.

NOTE In Switzerland, plugs and socket-outlets according to IEC 60309-2 are recommended for Mode 1 connections for more than 8 A (2 kVA).

6.2.2 Requirements of connection and/or disconnection process in AC contacts

6.2.2.1 Contact sequence

Earth contact, if any, shall close before line and neutral contacts.

The sequence of other contacts, if any, shall be specified by the vehicle manufacturer.

6.2.2.2 Removal sequence

Earth contact, if any, shall open after line and neutral contacts.

The sequence of other contacts, if any, shall be specified by the vehicle manufacturer.

6.2.3 Protection from unintended voltage for AC connection

The plug or vehicle inlet shall comply with at least one of the following requirements:

— the charge between any contacts shall be below 50 µC within 1 s after cut off of the external power supply;

— the voltage between any contacts shall be below 60 V DC and 30 V AC (rms) within 1 s after cut off of the external power supply.

NOTE Cut off of external power supply means loss of supply voltage, including disconnection and voltage outage on the supply.

6.2.4 Additional requirements for AC electric power supply

6.2.4.1 Load current

When the vehicle power supply circuit is connected to an external electric power supply, ISO 17409:2020, 8.2.1 shall apply.

6.2.4.2 Inrush current

For a vehicle power supply circuit intended to be connected with an EV supply equipment that is provided by the IEC 61851 series, ISO 17409:2020, 8.2.2 shall apply.

6.2.4.3 DC fault currents

Unless any measures to ensure a proper function of a RCD in the fixed electrical installation are considered outside the vehicle, at least one of the following requirements shall be fulfilled:

— vehicle power supply circuit shall ensure by its design that a DC fault current of 6 mA or above this limit cannot occur in a single fault condition;

— vehicle shall detect DC fault currents at the vehicle power supply circuit when connected to the external electric power supply. In case of DC fault currents exceeding 6 mA, the circuit supplying the DC fault current shall be switched off.

6.3 DC connection

6.3.1 Requirements of connection and/or disconnection process in DC contacts

For safety reasons, requirements of the connecting and disconnecting sequence shall be specified by the vehicle manufacturer.

6.3.2 Protection from unintended voltage for DC connection

The vehicle inlet shall comply with at least one of the following requirements:

— the energy of the total capacitance between any energized voltage class B live part and the electric chassis and/or exposed conductive parts shall be lower than 0,2 J at its maximum working voltage. Total capacitance should be calculated based on designed values of related parts and components;

— the voltage shall be below 60 V DC within 1 s after disconnection of the vehicle coupler.

These requirements shall be fulfilled in unmated portions of the vehicle inlet if other parts do not cover poles.

6.3.3 Specific requirements

Contacts shall be so designed as to ensure adequate contact pressure when completely engaged with the corresponding connection between the charger device and vehicle couplers or RESS of the vehicle. Contacts of RESS coupler and/or vehicle coupler shall be self-adjusting to ensure adequate contact pressure.

7 Protection against electric shock

7.1 General requirements

7.1.1 General requirements for connected sections of a circuit

If not specified otherwise, an electric circuit consisting of conductively connected sections with different maximum working voltages shall be classified according to the highest maximum working voltage.

7.1.2 General requirements for voltage class A

In the case of no galvanic separation or galvanic separation equivalent to basic insulation between the AC supply network (mains) and voltage class A circuits, the voltage class A circuit shall have the equivalent insulation as described in 7.3.4 and the equivalent potential equalization as described in 7.3.1.

NOTE If the insulations between the AC supply network (mains) and voltage class A circuits are only basic, the class A circuits can be hazardous-live-parts under single fault condition.

The electric chassis may be used as a conductor for the DC sections of a voltage class A electric circuit. The electric chassis shall not be used as a conductor for the AC sections of a voltage class A electric circuit.

An electric circuit may consist of sections with voltage class B1 and sections with voltage class A. In this case the following conditions shall apply.

— At a single fault in this circuit the voltage of the voltage class A sections shall not exceed the limits specified for voltage class A.

— The voltage class A sections shall be classified as voltage class A.

7.1.3 General requirements for voltage class B

According to IEC 61140, protection against electric shock shall be comprised of the following:

— basic protection: measures against direct contact with hazardous-live-parts;

— fault protection: measures for protection under single fault conditions.

7.2 Basic protection

For basic protection, the requirement of basic insulation shall be fulfilled.

The protective provisions in 7.4 shall apply.

Different measures to provide basic protection may be used for different sections of a circuit.

7.3 Fault protection and additional measures

7.3.1 Equipotential bonding

Exposed conductive parts of voltage class B electric equipment that can be touched by a test finger according to IPXXB (see ISO 20653) after removing all other parts that can be removed without using tools, shall be bonded to the electric chassis to achieve equipotentiality.

All components forming the equipotential bonding current path (conductors, connections) shall withstand the maximum current in a single fault condition.

The resistance of the equipotential bonding path between any two of these exposed conductive parts of the voltage class B electric circuit that can be touched simultaneously by a person shall not exceed 0,1 Ω.

The resistance of the path used for protective conductor connection shall be tested with a test current of at minimum 200 mA and a voltage <24 V DC The test current shall be passed through the protective conductor paths between the protective conductor terminal of the plug (case A) or vehicle inlet (case B and case C) and any connected conductive part of the vehicle power supply circuit and the electric chassis for at least 5 s. This path shall be isolated from other unintended potential paths for purpose of the test.

7.3.2 Alternative protection measures

The following measures shall provide both basic protection and fault protection:

— double insulation;

— reinforced insulation;

— protective barriers in addition to the basic protection;

— protective enclosures in addition to the basic protection;

— conductive protective barrier with equipotential bonding in addition to basic insulation;

— conductive protective enclosure with equipotential bonding in addition to basic insulation;

— rigid protective barriers with sufficient mechanical robustness and durability over the vehicle service life; and

— rigid protective enclosures with sufficient mechanical robustness and durability, over the vehicle service life.

The selected measure or combination of measures shall address the single fault for which it is intended.

Different measures may be used for different sections of a circuit.

7.3.3 Requirements for protective barrier or enclosures

If protection is provided by barriers/enclosures, hazardous-live-parts shall be placed inside enclosures or behind barriers, preventing access to the hazardous-live-parts from any usual direction of access.

The barriers/enclosures shall provide sufficient mechanical resistance under normal operating conditions, as specified by the manufacturer.

If barriers/enclosures are accessible directly, they shall be opened or removed only by use of tools or maintenance keys or they shall have means to deactivate hazardous-live-parts with class B voltage of the on-board charging system.

NOTE 1 Refer to 10.1 for marking on barriers/enclosures of voltage class B electric parts of the on-board charging system.

NOTE 2 Refer to 7.4.2 for the minimum degree of protection for a person against electrical shock on barrier/enclosures.

NOTE 3 The rigid barriers/enclosures include (but are not limited to) power control enclosures, motor housings, connector casings and housings, etc. They can be used as single measure instead of basic barriers/enclosures to meet both basic and single fault(s) protection requirements.

7.3.4 Requirements for insulation

If protection is provided by insulation, the hazardous-live-parts of the on-board charging system shall be totally encapsulated by insulation, which can be removed only by destruction or tools.

The insulating material shall be suitable to the maximum working voltage and operating/storage temperature ratings of the vehicle and its charging system.

Insulating varnish, dope, enamel, and other similar materials are not acceptable as basic insulation of the voltage class B components.

The insulation of the voltage class B components shall fulfill the withstand voltage capability according to the withstand voltage test in the 9.3.

7.4 Protection against access to hazardous-live-parts

7.4.1 General

The on-board charging components shall comply with the degree of protection IPXXB at minimum.

The on-board charging components shall meet their minimum degree of protection for person against electrical shock shown in Table 4.

If vehicle coupler parts and/or cable parts can be disconnected without tools, they shall comply with IPXXB at minimum in unmated condition for the contacts that can have class B voltage.

Table 4 — Degree of protection

Part	Minimum degree of protection
For charging assembly	IPXXD or IPXXB
For vehicle couplers mated	IPXXD
For plugs mated	IPXXD
For vehicle couplers not mated	IPXXD or IPXXB
For plugs not mated	See regulation of each country

7.4.2 Requirements of the degree of protection of barrier/enclosures against electric shock

Barriers/enclosures shall comply with the degree of protection IPXXB at minimum.

In case the barriers/enclosures can be intentionally or unintentionally accessed under normal conditions of use and without any tool by the rider, barrier/enclosures shall comply with the degree of protection IPXXD at minimum.

7.5 Insulation coordination

7.5.1 AC connection

The insulation of the vehicle power supply circuit shall be designed according to the circuit's maximum working voltage and overvoltage category II according to IEC 60664-1. If the vehicle power supply circuit includes measures that limit transient overvoltage to an appropriately low level, parts of the vehicle power supply circuit may be designed according to its maximum working voltage and overvoltage category I according to IEC 60664-1.

Conformance shall be tested in accordance with 9.3. Neither dielectric breakdown nor flashover shall occur during the test.

7.5.2 DC connection

The vehicle power supply circuit shall be designed according to a rated impulse voltage of at least 2 500 V.

Conformance shall be tested in accordance with 9.3. Neither dielectric breakdown nor flashover shall occur during the test.

NOTE According to IEC 61851–23, the DC charging station limits the overvoltage at its output to this value.

7.6 Touch current

Under single failure conditions the touch current of the vehicle shall not exceed 3,5 mA (rms) AC and 10 mA DC when the vehicle is connected to an external electric circuit.

Conformance shall be tested in accordance with ISO 17409:2020,13.6.

8 Protection against thermal incident

8.1 Overcurrent protection

8.1.1 Overload protection

The cross-sectional area of the live conductors of the vehicle power supply circuit, as well as the rated current of the plug (case A) or vehicle inlet (case B and case C), shall be according to the maximum load current of the vehicle unless parts of this circuit are separately protected by an overcurrent protection device in the vehicle. (e.g. fuse, circuit breaker, etc.)

8.1.2 Short circuit protection for AC connection

For short-circuit current supplied by external electric power supply, the requirements in a), b), or c) shall be fulfilled.

a) The cross-sectional area of the live conductors of the vehicle power supply circuit shall have a short circuit current withstand rating (I^2t) according to the characteristics of the overcurrent protection device of the external electric power supply.

   I^2t value shall be calculated according to IEC 60364-4-43.

   NOTE Breaking time for overcurrent protection device is less than 0,1 s (see IEC 60364–4-43).

b) An overcurrent protection device (e.g. fuse, circuit breaker) shall be provided in each live conductor of the vehicle power supply circuit. The cross-sectional area of the live conductor downstream this overcurrent protection device shall be designed according to the rating of this overcurrent protection device.

c) For case B and case C, all of the following requirements shall be fulfilled:

   — cross-sectional area of the vehicle power supply circuits shall be designed according to the maximum load current of the vehicle;

   — an overcurrent protection device (e.g. fuse, circuit breaker) shall be provided inside the charger. The overcurrent protection device rating and short-circuit current interrupt rating shall be sufficient to protect the wiring of the vehicle power supply circuit between the vehicle inlet and the on-board charger.

For short-circuit current supplied by power sources of the vehicle, overcurrent protection shall be provided for the vehicle power supply circuit.

8.1.3 Short-circuit protection for DC connection

For a vehicle power supply circuit intended to be connected with EV supply equipment provided by IEC 61851-23, ISO 17409:2020, 7.2.4 shall apply.

8.2 Arc protection for DC connections

The function for prevention of arcing shall be provided with EV supply equipment for power transfer with more than 5 A DC.

8.3 Residual energy after disconnection

One second after having disconnected the vehicle from the external electric power supply, the stored energy live parts at the plug (case A) or vehicle inlet (case B and case C), which are not protected at least by IPXXB in accordance with ISO 20653, shall be less than 20 J (see IEC 60950-1).

NOTE Circuits whose voltages are safe to touch can become hazardous with respect to energy related hazards.

9 Additional requirements and test procedure

9.1 General conditions on tests

All tests are type tests.

Room temperature is a temperature of (25 ± 2) °C.

If not otherwise specified, the tests described apply to the vehicle power supply circuit referred to as device under test.

Unless specified otherwise in the individual test method, the device under test shall be operated under normal operating conditions.

Unless specified otherwise in the individual test method, the tests shall be carried under normal laboratory conditions:

— Temperature: 15 °C to 35 °C;

— Air pressure: 86 kPa to 106 kPa at sea level;

— Relative humidity: 25 % to 75 %.

The accuracy of external measurement equipment shall be at least within the following tolerances:

— voltage: ±0,5 %;

— current: ±0,5 %;

— temperature: ±1 K.

The overall accuracy of externally controlled or measured values, relative to the specified or actual values, shall be at least within the following tolerances:

— voltage: ±1 %;

— current: ±1 %;

— temperature: ±2 K;

— time: ±0,1 %;

— mass: ±0,1 %;

— dimensions: ±0,1 %.

All values (time, temperature, current, and voltage) shall be noted at least every 5 % of the estimated time, except if it is noted otherwise in the individual test procedure.

If any test in this document is performed on the EV, the same test on component level is not necessary.

9.2 Protection against ingress of solid foreign objects and water

Vehicle connector when mated with vehicle inlet shall apply at least to the degree of protection IP44.

Conformance is checked by inspection or tests specified in ISO 20653.

9.3 Withstand voltage test

9.3.1 General

The withstand voltage test according to ISO 6469-3:2021, applies with the following modifications:

— The test is performed on the on-board section of the vehicle power supply circuit at the contacts of the plug (case A), or vehicle inlet (case B and case C).

— If the on-board section of the vehicle power supply circuit includes contactors or disconnection devices, they are closed.

The test voltage is as specified in 9.3.2.

9.3.2 Test voltage

9.3.2.1 AC connection

The RMS value of the AC test voltage of a frequency of 50 Hz or 60 Hz is raised uniformly from 0 V to the following value within not more than 5 s and held at that value for at least for 60 s:

— (Un + 1 200 V) if basic insulation applies;

— 2 × (Un + 1 200 V) if double insulation or reinforced insulation applies,

where Un is the nominal line to neutral voltage of the neutral-earthed supply system.

NOTE The values for AC test voltage originate from IEC 60664-1:2007, 5.3.3.2.3 and IEC 60364-4-44:2007, 442.2.2.

Equivalent values of the DC voltage can be used instead of the AC peak values. The equivalent DC test voltage is 1,41 times of the RMS value of the AC voltage.

Further test conditions conform to IEC 60664-1, considering the specific operating conditions as specified by the vehicle manufacturer.

9.3.2.2 DC connection

The test voltage is derived from the relevant overvoltage of the electric circuit to which the component is connected. Transient overvoltage that can be expected, including influences from other connections to grid, if any, is included. The test voltage and its duration are specified, considering the applicable parts and sections of the IEC 60664 series by the vehicle manufacturer.

9.3.3 Dielectric withstand voltage of voltage class A direct current part

In case of double insulation and/or reinforced insulation applying in between the AC or DC parts of class B voltage and DC parts of class A voltage, the dielectric withstand voltage expressed in V shall be equal to (2 *Ur* + 500) V AC (rms) for 2 min and applied between live parts and other exposed metal parts only, where *Ur*, expressed in volts, is the rated voltage of the electric circuit of voltage class A.

9.4 Isolation resistance

9.4.1 General

The voltage class B electric circuits of the on-board charging equipment shall have sufficient isolation resistance.

That isolation resistance, divided by the maximum working voltage, shall have a minimum value of 100 Ω/V for DC circuits and a minimum value of 500 Ω/V for AC circuits.

NOTE According to IEC TS 60479-1, body currents within zone DC-2 or zone AC-2 are not harmful. The currents calculated from 100 Ω/V for DC and 500 Ω/V for AC are 10 mA DC and 2 mA AC respectively, and within these zones.

To meet the above requirement for the entire circuit of the on-board charging equipment, it is necessary to provide a higher isolation resistance for each component, depending on the number of the components and the structure of the circuit to which they belong.

If DC and AC voltage class B electric circuits are conductively connected, one of the following two requirements shall be fulfilled for the conductively connected circuit.

— Option 1: Isolation resistance, divided by the maximum working voltage, shall have a minimum value of 500 Ω/V for the combined circuit.

— Option 2: Isolation resistance, divided by the maximum working voltage, shall have a minimum value of 100 Ω/V, if at least one of the alternative protections measures as specified in 7.3.2 is applied to the AC circuit.

Conformance shall be tested in accordance with ISO 13063-3:2022, 11.3.

9.4.2 Additional measures at a non-maintained isolation resistance

If the minimum isolation resistance requirement of a voltage class B circuit of the on-board charging equipment, cannot be maintained under all operational conditions and over the entire service life, one of the following measures shall be applied.

— The isolation resistance shall be monitored before charging. An appropriate warning shall be provided if the minimum isolation resistance requirement is violated. The voltage class B circuit of the on-board charging equipment shall be deactivated if the vehicle is being charged (see Annex B if charging type B). The isolation resistance monitoring system shall be tested in accordance with ISO 13063-3:2022, 11.4.

— Alternative protection measures according to 7.3.2.

9.5 Creepage distance and clearance

The creepage distance and clearance shall be according to ISO 13063-3:2022, 7.6.

9.6 Requirements for the emission of hazardous gases and other hazardous substances

To prevent explosion, fire or toxicity hazards, the following requirements apply when hazardous gases and other substances can be emitted by the RESS. These requirements shall consider normal operating

and environmental conditions. No potentially dangerous concentration of hazardous gases and other hazardous substances shall be allowed around the vehicle.

Refer to the latest version of applicable national/International Standards or regulations for the maximum allowed accumulated quantity of hazardous gases and other substances.

Appropriate countermeasures shall manage single fault situations.

9.7 Permissible surface temperature

The maximum permissible surface temperature of the on-board charging equipment that is touched but not grasped, at the maximum rated current and at ambient temperature of 40 °C, shall be

— 70 °C for metal parts, and

— 85 °C for non-metallic parts.

9.8 Unintentional charging system behaviour

9.8.1 General

Unintentional behaviour of the on-board charging equipment caused by single-point man-made, hardware or software fault(s) (single fault(s)) during operation in the system and components specific to EVs and on-board charging equipment shall be minimized.

9.8.2 Unintended reverse power flow

An unintended reverse power flow from the vehicle to the external electric power supply shall not be permitted under normal operation and single fault conditions.

9.9 Electromagnetic compatibility

9.9.1 Susceptibility

Care shall be taken to minimize electromagnetic susceptibility of the on-board charging equipment, taking into account national standards or regulations and International Standards.

9.9.2 Emissions

Care shall be taken to minimize electromagnetic emission from the on-board charging equipment, taking into account national standards or regulations and International Standards.

9.10 Service

The on-board charging equipment shall be designed so that vehicle manufacturers' certified technicians may remove, service and replace it if necessary.

10 Marking, instructions, and indications

10.1 Marking

The symbol shown in Figure 4 shall appear on (preferably) or near voltage class B parts of the on-board charging equipment. The same symbol shall be visible on barriers and enclosures, which, when removed, expose live parts of voltage class B circuits. Accessibility and removability of barriers/enclosures should be considered for the necessity of the symbol. The symbol background shall be yellow, the bordering and the arrow shall be black in accordance with ISO 7010-W012.

Figure 4 — Symbol ISO 7010-W012

10.2 Legibility

The markings required by this document shall be legible with corrected vision, durable and visible during use.

The marking shall have a good contrast with their background. If the indication may be placed on a vehicle, parts of a vehicle or the on-board charging equipment, the indication may be viewed by the rider from one's normal seated position.

10.3 Connection instructions

Instructions for the connection of the vehicle to an external electric power supply shall be provided with place of manufacturer indicating and/or the user's manual.

10.4 Indication

The on-board charging equipment may be able to indicate that the vehicle is properly connected to an external electric power supply. The indication may be easily recognizable by the person who carries on the charging.

The on-board charging equipment may be able to indicate that the vehicle is ready for energy to be supplied from the external electric power supply. The indication may be easily recognizable by the person who carries on the charging.

The indication shall have a good contrast with their background. If the indication may be placed on a vehicle, parts of a vehicle or the on-board charging equipment, the indication may be viewed by the rider from rider's normal seated position.

The information necessary for:

— installation;

— operation; and

— maintenance;

of the "charger" and any components shall be supplied in appropriate forms such as:

— drawings;

— diagrams;

— charts;

— tables; and

— instructions.

Annex A
(informative)

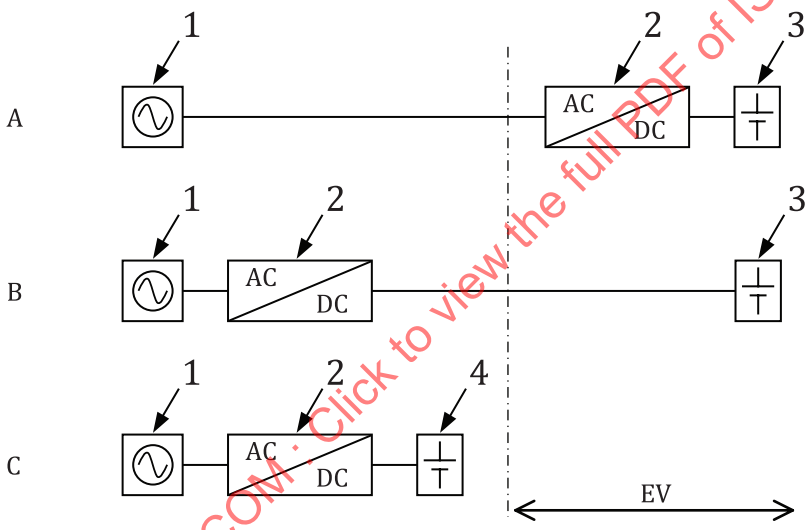
Charging types

A.1 Classification

A.1.1 General

The charging types are classified based on the location of the EV supply equipment and the RESS as shown in Figure A1.

NOTE As described in IEC 61851-1:2017, 5.5, EV supply equipment can be classified as stationary, portable, or mobile equipment.



Key

1	AC supply network	A	charging type A
2	charger or EV supply equipment	B	charging type B
3	RESS	C	charging type C
4	removable RESS		

Figure A.1 — Classification of charging type

A.1.2 Charging type A

The charger and the RESS are not able to be removed from the EV and are connected to the supply network by

— a charging cable which is permanently connected to the EV (case A), and

— a vehicle inlet which is permanently mounted to the EV (case B and/or case C).

NOTE The case A, case B and case C are defined in IEC 61851-1:2017, 3.1.10, 3.1.11 and 3.1.12.