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Electrically propelled road vehicles — Functional and safety requirements for power transfer between vehicle and external electric circuit —

Part 3: DC power transfer

Véhicules routiers à propulsion électrique — Exigences fonctionnelles et exigences de sécurité pour le transfert de puissance entre le véhicule et le circuit électrique externe —

Partie 3: Transfert de puissance DC

Reference number
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Foreword

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This document was prepared by Technical Committee ISO/TC 22 *Road vehicles*, Subcommittee SC 37 *Electrically propelled vehicles*.

A list of all parts in the ISO 5474 series can be found on the ISO website.

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Electrically propelled road vehicles — Functional and safety requirements for power transfer between vehicle and external electric circuit —

Part 3:
DC power transfer

1 Scope

This document in combination with ISO 5474-1 specifies requirements for conductive power transfer using direct current (DC) with a voltage up to 1 500 V d.c. between electrically propelled road vehicles and external electric circuits.

This document provides requirements for conductive charging in mode 4 according to IEC 61851-1. For mode 4, this document provides requirements regarding the power transfer only with isolated DC EV supply equipment according to IEC 61851-23.

The requirements in this document are applicable to vehicle power supply circuits.

An outlook of requirements for megawatt charging applications is given in Annex B.

This document does not provide:

— requirements for simultaneous operation of multiple power transfer interfaces and

— requirements for power transfer while driving (electric road systems)

but they are under consideration.

This document does not provide:

— requirements for mopeds and motorcycles (which are specified in ISO 18246);

— comprehensive safety information for manufacturing, maintenance and repair personnel.

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 5474-1:2024, *Electrically propelled road vehicles —Functional requirements and safety requirements for power transfer —Part 1: General requirements for conductive power transfer*

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

ISO 26262 (all parts), *Road vehicles — Functional safety*

IEC 60364-4-43, *Low-voltage electrical installations — Part 4-43: Protection for safety — Protection against overcurrent (relevant parts will be specified during the project)*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques - Surge immunity test*

IEC 61180, *High-voltage test techniques for low-voltage equipment — Definitions, test and procedure requirements, test equipment*

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

IEC 61851-23:2023, *Electric vehicle conductive charging system — Part 23: DC electric vehicle charging station*

IEC 62196-3, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 3: Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and contact-tube vehicle couplers*

IEC TS 62196-3-1, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 3-1: Vehicle connector, vehicle inlet and cable assembly for DC charging intended to be used with a thermal management system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5474-1 and the following 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
cut-off current
let-through current
maximum instantaneous value of current attained during the breaking operation of a switching device or a fuse

Note 1 to entry: This concept is of particular importance when the switching device or the fuse operates in such a manner that the prospective peak current of the circuit is not reached.

[SOURCE: IEC 60050-441:1984, 441-17-12, modified — “is” added to the Note to entry.]

3.2
insulation monitoring device
IMD
device which permanently monitors the insulation resistance to earth of unearthed AC IT systems, AC IT systems with galvanically connected DC circuits having nominal voltages up to 1 000 V a.c., as well as monitoring the insulation resistance of unearthed DC IT systems with voltages up to 1 500 V d.c., independent from the method of measuring

[SOURCE: IEC 61557-8:2014, 3.1.14]

3.3
insulation resistance monitoring system
system that periodically or continuously monitors the insulation resistance between live parts and the electric chassis

[SOURCE: ISO 6469-3:2021, 3.24, modified — "isolation" has been replaced by "insulation".]

3.4
thermal cut-out
temperature sensing control device intended to switch-off automatically under abnormal operating conditions and which has no provision for adjustment by the user

[SOURCE: IEC 60050-442:1998, 442-01-43]

3.5
thermal sensing
means for providing temperature data of accessories, cable assemblies or parts thereof

[SOURCE: IEC 61851-23:2023, 3.3.109]

3.6
RESS SOC
rechargeable energy storage system state of charge
residual capacity of RESS available to be discharged

Note 1 to entry: RESS state of charge is normally expressed as a percentage of full charge.

[SOURCE: ISO/TR 11954:2008, 2.2]

3.7
leakage current monitoring device
passive electrical device for monitoring insulation resistance of separated DC system by measuring leakage current between live parts and exposed conductive parts or the protective conductor

[SOURCE: IEC 61851-23:2023, 3.2.104, modified — Deprecated term removed.]

3.8
SPD
surge protective device
device that contains at least one non-linear component that is intended to limit surge voltages and divert surge currents

[SOURCE: IEC 61643-11:2011, 3.1.1]

4 System architecture

ISO 5474-1:2024, Clause 4 applies.

5 Environmental and operational conditions

ISO 5474-1:2024, Clause 5 applies.

6 Safety requirements

6.1 General

ISO 5474-1:2024, 6.1 applies except as follows.

Protection against electric shock for the vehicle power supply circuit shall comprise a provision for basic protection and a provision for fault protection according to the requirements in 6.2.

Unless specified otherwise, “Alternative protection measures” according to ISO 6469-3:2021, 6.3.5 shall be applied directly between live parts of the vehicle power supply circuit and an ordinary person.

For all safety related functions, the vehicle shall carry out its own measurement of current and voltage, and shall not solely rely on values communicated via digital communication by the EV supply equipment.

NOTE Digital communication is considered to be not reliable in terms of safety.

6.2 Protection of persons against electric shock

6.2.1 General

ISO 5474-1:2024, 6.2.1 applies.

6.2.2 Compatibility with external safety devices

6.2.2.1 Insulation resistance monitoring system

The operation of the insulation monitoring device or/and the leakage current monitoring device of the external electric circuit, as specified in IEC 61851-23, shall not be affected. The vehicle should deactivate or disconnect its insulation resistance monitoring system to avoid such interference.

6.2.2.2 Compatibility of a 1 000 V vehicle with 500 V EV supply equipment

If the vehicle contains circuits with a maximum working voltage between DC+ and DC- above 500 V and it is intended to be connected to DC EV supply equipment with a rated maximum DC output voltage below or equal to 500 V d.c., there is a risk that the voltage between the live conductors and protective conductor in the EV supply equipment exceeds 500 V. It can be caused by, but is not limited to, an insulation fault, see Figure 1, or asymmetric distribution of the insulation resistance between DC+/DC- and the protective conductor in the section of the vehicle with a working voltage above 500 V d.c.

The temporary overvoltage can trip SPDs in the EV supply equipment or damage components in the EV supply equipment.

The current caused by those effects can subsequently:

— cause a touch voltage between earth and vehicle chassis, and/or

— damage the protective conductor connection between the vehicle and the DC supply equipment as a secondary effect.

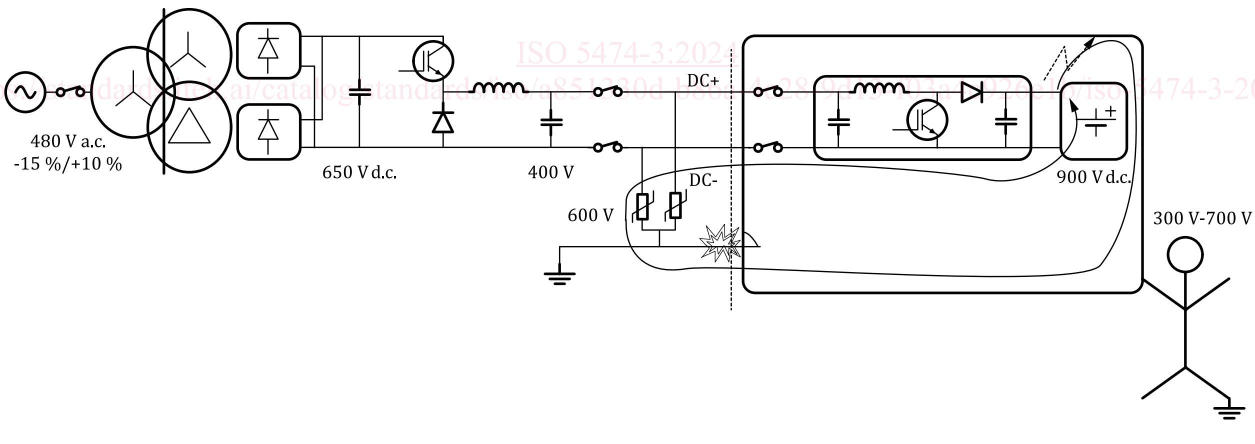

Figure 1 — Single fault scenario of a 1 000 V vehicle with 500 V EV supply equipment

The vehicle manufacturer shall perform a safety analysis to minimize the risk of a hazardous electric shock caused by the effects above. The protection measures are, but not limited to:

— the vehicle shall disconnect the vehicle power supply circuit from the EV supply equipment in less than 5 s if the voltage between the live conductors and protective conductor exceeds 500 V in the section of the vehicle power supply circuit with a working voltage of less than or equal to 500 V;

— the vehicle shall fulfil at least one of the following:

a) have a vehicle power supply circuit with a maximum working voltage up to 500 V and provide simple separation between the vehicle power supply circuit and any circuit which has a working voltage above 500 V;

b) implement double or reinforced insulation between the live parts of the vehicle power supply circuit (including the RESS) with a working voltage above 500 V and electric chassis/voltage class A circuit;

c) limit the operating joule integral I^2t in consideration of IEC 60364-5-54 and limit the duration of touch voltage between electric chassis and earth or EV supply equipment housing in consideration of IEC 60479 series.

6.2.2.3 Y-capacitance coordination

The total y-capacitance of the vehicle power supply circuit shall not exceed 4 µF.

For a vehicle equipped with a vehicle inlet according to IEC TS 62196-3-1 or IEC 62196-3 configuration AA with a maximum working voltage up to 500 V d.c., the y-capacitance of the vehicle power supply circuit shall not exceed 1,1 µF per live conductor and 2,2 µF in total y-capacitance.

For a vehicle with a vehicle inlet according to IEC TS 62196-3-1 or IEC 62196-3 configuration AA, configuration EE or configuration FF and a maximum working voltage above 500 V d.c., the total y-capacitance of the vehicle power supply circuit shall not exceed the limits according to Formula (1).

$$C_y = \frac{1,6}{1\,000 * U} \qquad (1)$$

where

C_y is the total y-capacitance, expressed in Farad (F);

U is the maximum working voltage, expressed in Volt (V).

NOTE The formula assumes a measurement current of the IMD of 1 mA and limits the time to perform a single measurement for one live conductor to 8 s. This supports a total time for a complete measurement cycle for the vehicle of 30 s without consideration of the added y-capacitance of the external electric circuit.

For a vehicle with a vehicle inlet according to IEC TS 62196-3-1 or IEC 62196-3 configuration BB the Y-capacitance of the EV supply equipment shall be considered.

The y-capacitance per live conductor should be balanced by choosing appropriate design values.

Conformance is checked by inspection and by test. An example for a test is given in Annex A.

6.2.2.4 Compatibility with the special protection of the DC EV supply equipment

To support the special protection of the DC EV supply equipment, the total y-capacitance of the vehicle power supply circuit shall not exceed the limits according to 6.2.2.3.

NOTE 1 The special protection is provided by the DC EV supply equipment according to IEC 61851-23:2023, 8.105.1.

NOTE 2 The Y capacitance threshold from 6.2.2.3 by itself does not provide additional protection for vehicles with a maximum working voltage above 500 V d.c. when the vehicle is disconnected from the DC EV supply equipment. For protection of persons against electric shock when not connected to an external electric circuit, see ISO 6469-3.

6.2.3 Insulation resistance

ISO 5474-1:2024, 6.2.3 applies.

6.2.4 Touch current

ISO 5474-1:2024, 6.2.4 applies except as follows.

Conformance shall be tested in accordance with 12.5.

6.2.5 Insulation coordination

The vehicle shall provide one of the following provisions between voltage class B live parts of the vehicle power supply circuit and an accessible voltage class A circuit:

— protective separation;

— basic insulation and, under single fault condition, limitation of the voltage at the accessible voltage class A terminals of a voltage class B component to below 60 V d.c. (or 30 V a.c.). Voltage transients exceeding 60 V shall be limited with an adequate margin from ventricular fibrillation in accordance with IEC 60479 series. The margin shall be specified by the vehicle manufacturer;

  Conformance shall be checked by either design review or conformance test as specified by the vehicle manufacturer. An example is given in C.1.

— basic insulation and, under single fault condition, limitation of:

  a) steady-state touch current between the accessible voltage class A terminals of a voltage class B component and accessible conductive parts to 3,5 mA a.c. and 10 mA d.c.;

  b) touch energy below a value with an adequate margin from the limit of ventricular fibrillation in accordance with IEC 60479 series; the margin shall be specified by the vehicle manufacturer.

  Conformance shall be checked by either design review or conformance test as specified by the vehicle manufacturer. An example is given in C.2.

The insulation between DC+ and protective conductor as well as DC- and protective conductor of the vehicle power supply circuit shall be designed to withstand:

— impulse withstand voltage of at least 2 500 V;

— short-term temporary overvoltage of 1 980 V d.c. with durations up to 5 s;

— long-term temporary overvoltage of 550 V d.c. with durations longer than 5 s if the vehicle power supply circuit has a maximum working voltage between DC+ and DC- up to 500 V d.c.;

— long-term temporary overvoltage of 110 % of the maximum working voltage between DC+ and DC- with durations longer than 5 s if the vehicle power supply circuit has a maximum working voltage between DC+ and DC- above 500 V d.c.

NOTE 1 The value of 1 980 V is based on the equation $(U_n + 1\ 200) \cdot \sqrt{2}$ from IEC 61851-23:2014 with an assumed value of $U_n = 200$ V.

NOTE 2 IEC 61851-23:2023 specifies a short-term temporary overvoltage of 1 800 V.

NOTE 3 These requirements are derived from IEC 61851-23. See also IEC 60664-1:2020, Clause 5.

Conformance shall be tested in accordance with 12.4.1.

For normal operation the vehicle power supply circuit shall be designed for a maximum voltage between DC+ and protective conductor as well as between DC– and protective conductor of at least the maximum DC working voltage.

Additional voltages of the insulation monitoring device (IMD) of the external electric circuit (see IEC 61851-23) shall be considered.

6.2.6 Protective conductor

ISO 5474-1:2024, 6.2.6 applies except as follows.

For cross-sectional area of the protective conductor, see also IEC 61851-23:2023, 8.105.11.