



Technical Specification

ISO/TS 5474-5

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

Part 5: Automatic conductive power transfer

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

Partie 5: Transfert de puissance automatique par conduction

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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document 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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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.

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 specifies requirements for the onboard side of an automatic connection system to charge electric vehicles. It gives guidance in terms of safety and compatibility with the offboard side of automatic connection systems.

Technological maturity:

It is pointed out, that this document has been established in parallel to the technological development of automatic connection systems. Due to the fact that the experience with the technology is very limited, the requirements given in this document do not comprehensively cover all aspects/requirements for an interoperable operation at this stage. Current and future product developments will continuously prove, disprove and refine the requirements of this document.

Furthermore, it is worthwhile to mention that at the date of publication of this document, no standard for a vehicle coupler of category 3 (at the underbody of the vehicle) is available.

Relation to other parts of the ISO 5474 series:

There is no direct relation of content or structure of this document to any other part of the ISO 5474 series (including ISO 5474-1). Wherever needed, other parts of the series are specifically referenced.

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

Part 5: Automatic conductive power transfer

1 Scope

This document defines requirements for the onboard system (vehicle side) related to the automatic connection for conductive alternating current (AC) and/or direct current (DC) power transfer between electrically propelled road vehicles (EVs) and external electric circuits. This document addresses the following aspects:

- electrical and mechanical safety requirements;
- compatibility requirements;
- environmental conditions;
- functionality requirements;
- test procedures.

This document applies to:

- EVs supporting automatic connection of a vehicle inlet according to IEC 62196-2, IEC 62196-3, IEC TS 62196-3-1 or IEC TS 63379¹⁾ (category 1) and
- EVs supporting automatic connection of a category 3 vehicle inlet or category 3 plug (typically at the underbody of the vehicle) according to IEC TS 61851-26.

NOTE 1 IEC TS 61851-26 does not include automatic connection of vehicle inlets or plugs of category 1 and category 2, that can also be mounted at the underbody of the vehicle.

Requirements for EVs equipped with an ACD or ACD counterpart of category 2 are specified in EN 50696 and IEC 63407²⁾.

Requirements for simultaneous operation of multiple power transfer interfaces are under consideration and not covered in this document.

NOTE 2 Requirements for ACD infrastructure, communication sequence and communication interface are specified in IEC 61851-23-1, IEC TS 61851-26 and IEC TS 61851-27.

NOTE 3 EMC requirements for vehicles conductively connected to the supply network are defined in IEC 61851-21-1.

1) Under preparation. Stage at the time of publication: IEC TS/CDM 63379:2023.

2) Under preparation. Stage at the time of publication: IEC/CDM 63407:2023.

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 5474-1³⁾, *Electrically propelled road vehicles — Functional requirements and safety requirements for power transfer — Part 1: General requirements for conductive power transfer*

ISO 5474-2⁴⁾, *Electrically propelled road vehicles — Functional requirements and safety requirements for power transfer — Part 2: AC power transfer*

ISO 5474-3⁵⁾, *Electrically propelled road vehicles — Functional requirements and safety requirements for power transfer — Part 3: DC power transfer*

ISO 10218-1:2011, *Robots and robotic devices — Safety requirements for industrial robots — Part 1: Robots*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

IEC TS 61851-26⁶⁾, *Electric vehicle conductive charging system — Part 26: EV supply equipment with automated connection of a vehicle coupler located at the underbody of an electric vehicle*

IEC TS 61851-27⁷⁾, *Electric vehicle conductive charging system — Part 27: EV supply equipment with automated connection of a vehicle coupler according to IEC 62196-2 or IEC 62196-3*

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

ACD onboard system

system with automatic *docking* (3.6) and *undocking* (3.14) functions installed in a vehicle and used in combination with an *automatic EV supply equipment* (3.3)

3.2

automatic connection device

ACD

active device where the physical connection between an electric vehicle (EV) supply equipment and vehicle is made without user interaction providing an electromechanical interface

Note 1 to entry: Preparatory steps taken by the user to allow for automatic charging (e.g. opening inlet cover) are not seen as part of establishing the physical connection.

Note 2 to entry: This term is derived from the term automated connection device.

[SOURCE: IEC 61851-23-1:—⁸⁾, 3.1.203, modified — The original term was "automated connection device" and Notes to entry were added.]

- 3) Under preparation. Stage at the time of publication: ISO/FDIS 5474-1:2024.
- 4) Under preparation. Stage at the time of publication: ISO/FDIS 5474-2:2024.
- 5) Under preparation. Stage at the time of publication: ISO/FDIS 5474-3:2024.
- 6) Under preparation. Stage at the time of publication: IEC/CD TS 61851-26:2023.
- 7) Under preparation. Stage at the time of publication: IEC/CD TS 61851-27:2023.
- 8) Under preparation. Stage at the time of publication: IEC/CDV 61851-23-1:2023.

3.3

automatic EV supply equipment

electric vehicle (EV) supply equipment with automatic *docking* (3.6) and *undocking* (3.14) functions

3.4

communication for docking and undocking

communication between the *supply equipment communication controller (SECC)* (3.13) and the *electric vehicle communication controller (EVCC)* (3.7) for *docking* (3.6) and *undocking* (3.14)

3.5

communication for power transfer

communication session established between the *supply equipment communication controller (SECC)* (3.13) and the *electric vehicle communication controller (EVCC)* (3.7), used for charging control

3.6

docking

process in which a *manipulator* (3.9) performs a controlled motion and mates either a plug to a socket-outlet or a vehicle connector to a vehicle inlet

Note 1 to entry: Other actuators in addition to the manipulator might be used, e.g. for opening of the inlet cover or for drawing the vehicle connector into the vehicle inlet.

3.7

EV communication controller

EVCC

embedded system, within the electric vehicle (EV), that implements the communication between the EV and the *supply equipment communication controller (SECC)* (3.13) in order to support specific functions

Note 1 to entry: Such specific functions could be, e.g. controlling input and output channels, encryption, or data transfer between EV and *SECC* (3.13).

[SOURCE: ISO 15118-1:2019, 3.1.31, modified — “vehicle” was replaced by “electric vehicle”.]

3.8

immobilization

inhibition of vehicle movement by its own propulsion system

3.9

manipulator

machine, the mechanism of which usually consists of a series of segments jointed or sliding relative to one another, for the purpose of grasping and/or moving objects (pieces or tools) usually in several degrees of freedom

[SOURCE: ISO/TR 11065:1992, 387, modified — Second sentence deleted.]

3.10

mating space

spatial envelope of points with specified range of orientations where mating of the vehicle connector and vehicle inlet or plug and socket-outlet is possible

3.11

package space

space around the vehicle inlet or socket-outlet where no obstacles are allowed

3.12

point to point signal

P2PS

unidirectional wireless link between the electric vehicle (EV) and *automatic EV supply equipment* (3.3)

Note 1 to entry: The P2PS is used for identification and for position detection of vehicle inlet or socket-outlet in the context of *docking* (3.6).

EXAMPLE Image recognition with camera-based inlet detection.

[SOURCE: IEC 61980-2:2021, 3.17, modified — “EV device” changed to “EV”, “supply device” changed to “EV supply equipment” and Note 1 to entry added.]

3.13

supply equipment communication controller

SECC

entity which implements the communication to one or multiple *electric vehicle communication controller(s) (EVCC) (s)* (3.7)

Note 1 to entry: Further details regarding possible architectures are given in ISO 15118-1:2019, Annex A.

Note 2 to entry: Functions of a supply equipment communication controller can control input and output channels, data encryption, or data transfer between the *EVCC* (3.7) and *SECC* (3.12).

[SOURCE: ISO 15118-1:2019, 3.1.68, modified — “and which may be able to interact with secondary actors” is deleted, Note 1 to entry is deleted, in Note 2 to entry “ISO 15118-1:2019” is added and in Note 3 to entry “may” is replaced by “can” and “vehicle” is replaced by “EVCC”.]

3.14

undocking

process in which a *manipulator* (3.9) performs a controlled motion and unmates either a plug from a socket-outlet or a vehicle connector from a vehicle inlet

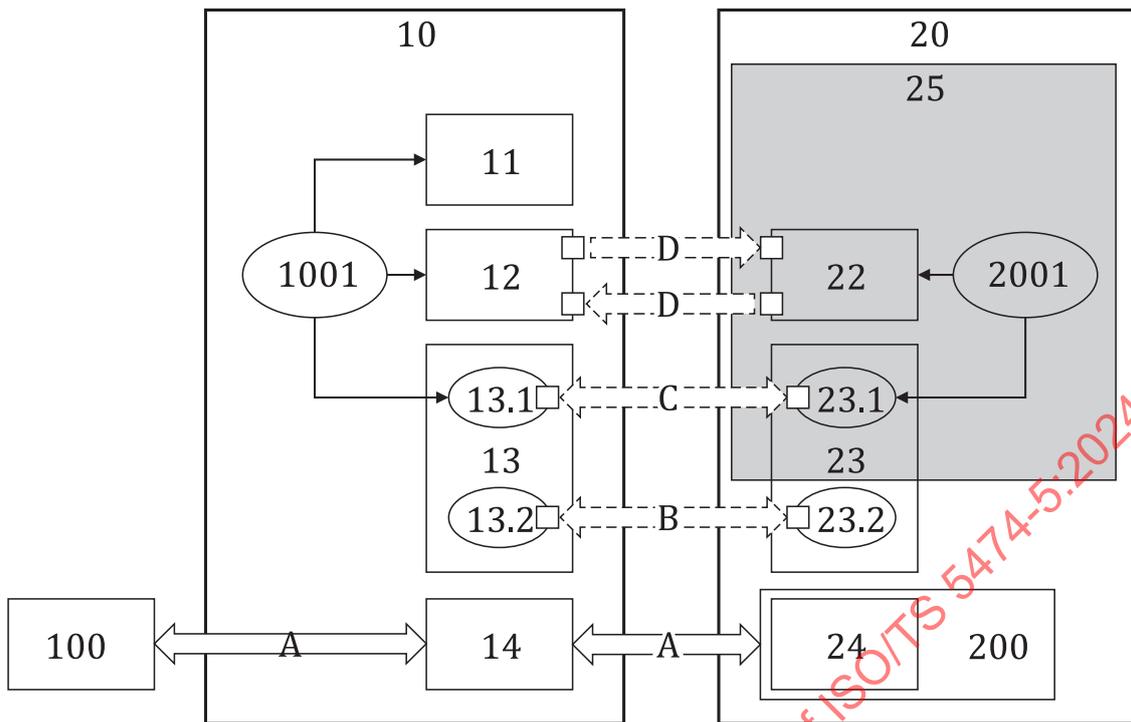
Note 1 to entry: Other actuators in addition to the manipulator might be used, e.g. for closing of the inlet cover or for ejecting the vehicle connector from the vehicle inlet.

4 System architecture

4.1 General

To establish a general baseline for the requirements defined in this document, the automatic charging system is structured into functional entities. [Figure 1](#) shows an example of the system architecture including a structure of functional entities.

NOTE The same example of system architecture is used in IEC TS 61851-26 and IEC TS 61851-27.



Key

10	automatic EV supply equipment	20	EV
11	manipulator	22	EV P2PS controller
12	supply equipment P2PS controller	23	EV communication controller (EVCC)
13	supply equipment communication controller (SECC)	23.1	EVCC.docking and undocking function
13.1	SECC.docking and undocking communication function	23.2	EVCC.power transfer communication function
13.2	SECC.power transfer communication function	24	vehicle inlet
14	vehicle connector	25	ACD onboard system
100	supply network	200	vehicle power supply circuit
1001	docking and undocking function of the automatic EV supply equipment	2001	docking and undocking control function of the ACD onboard system
A	power transfer	C	docking and undocking communication
B	power transfer communication	D	P2PS signalling

NOTE 1 The dashed arrows symbolize communication links, small squares located on both ends of arrows show connecting points of those and the arrows from boxes 1001 and 2001 symbolize that one functional entity uses another one.

NOTE 2 Details about the components included in the vehicle power supply circuit are given in ISO 5474-1.

NOTE 3 [Figure 1](#) is not meant to give an indication on hardware packaging.

NOTE 4 P2Ps signalling is shown with two unidirectional arrows as it is not yet finalized.

Figure 1 — Example of system architecture with manipulator on automatic EV supply equipment side

In case of a vehicle inlet or plug at the underbody of the vehicle, the EV shall provide measures to limit the pollution of that vehicle inlet or plug to the maximum pollution degree the vehicle inlet or plug is designed for.

6 General safety requirements

6.1 General

Unless otherwise specified in this document:

- the requirements of ISO 5474-2 shall apply in combination with the requirements of ISO 5474-1 in case of AC power transfer and
- the requirements of ISO 5474-3 shall apply in combination with the requirements of ISO 5474-1 in case of DC power transfer.

6.2 Compatibility with interlock of the automatic EV supply equipment

If the manipulator is attached to the EV:

- and if the automatic EV supply equipment is equipped with a mechanical interlock, the manipulator shall only unmate when the latching device is disengaged and
- the maximum force of the manipulator for unmatting shall be below the retaining force of the latching device of the automatic EV supply equipment.

6.3 Protection against mechanically caused injury

6.3.1 Limitation of force

The force and pressure created by the movement of accessible parts of the vehicle that are automatically moved for docking or undocking shall be limited to values that are considered non-hazardous according to the accessibility of the area (e.g. restricted/unrestricted access) where the vehicle is operated. These values shall be maintained both under normal conditions and under conditions of single failure.

Safety shall be assured by following the three-step method according to ISO 12100:2010, Clause 6.

It is recommended to assure mechanical safety by having applied step 1 of the three-step method according to ISO 12100:2010, Clause 6.

When the above recommendation is not applied to assure safety, protective measures shall be assessed according to ISO 10218-1:2011, 5.4.

In case of unrestricted access, the maximum permissible pressure and force, resulting of quasi static or transient contact shall be according to [Table 1](#).

NOTE The values are based on EN 12453:2017+A1:2021, 5.2.1.6 and EN 12453:2017+A1:2021, Annex A.

Table 1 — Maximum permissible forces

Type of contact	Maximum permissible force
Quasi static contact	150 N, automatically reduced to 25 N after maximum 5 s
Transient contact	400 N for up to 0,75 s

Conformance shall be shown by calculation or by test.

6.3.2 Maximum velocity and energy

The maximum velocity of accessible parts of the vehicle that are automatically moved for docking or undocking shall not exceed 250 mm/s.

NOTE 1 The requirement is based on ISO 10218-1:2011, 3.19.2.

A higher velocity is allowed if the kinetic energy does not exceed 1,69 J.

NOTE 2 The requirement is based on EN 16005:2012, 4.6.4.1.

7 Functional requirements

7.1 Vehicle position

A vehicle may be equipped with a vehicle positioning system.

The specifications in this document assume that the dimensions of the mating space in combination with typical tolerances in parking position allow for mating without additional guidance of the driver. Additional guidance can be offered for convenience reasons. This option is considered in the communication specification used in IEC TS 61851-26 and IEC TS 61851-27.

7.2 Compatibility with vehicle inlet position detection by the automatic EV supply equipment

During docking, the vehicle should turn off potential sources of disturbance (e.g. artificial inlet illumination for customer support) for the detection of the position of the vehicle inlet by the automatic EV supply equipment.

7.3 Manipulator requirements

7.3.1 General

If the vehicle is equipped with a manipulator, it shall only move the manipulator:

- after the vehicle is immobilized in a position such that the manipulator can reach the mating space of the socket-outlet, see IEC TS 61851-26;
- after establishing communication with the automatic EV supply equipment and having received confirmation that the automatic EV supply equipment is compatible and ready for docking;
- within the package space specified for automatic conductive power transfer with the socket-outlet and

NOTE 1 If the vehicle is equipped with a plug where a specific package space for automatic conductive power transfer with the socket-outlet is not specified in the product standard, see IEC TS 61851-26 for information.

- outside the package space specified for automatic conductive power transfer with the socket outlet if the vehicle uses obstacle detection.

If the vehicle is equipped with a manipulator, the manipulator shall be designed such that a movement/displacement according to [7.7.2](#) does not cause a damage to any part of the vehicle or the automatic EV supply equipment or lead to an unsafe situation during mating, unmating and power transfer.

NOTE 2 The ground clearance of the EV can be reduced actively (e.g. by air suspension systems) considering related safety requirements, accordingly.

7.3.2 Manipulator timing consideration

The ACD onboard system shall consider the timing specification for the manipulator operations according to IEC TS 61851-26 and IEC TS 61851-27.

NOTE Without timing considerations, collisions with automatic closing or opening covers could occur.

EXAMPLE Latching or unlatching could be initiated too early or too late, respectively.

7.4 Mating space and package space

7.4.1 General

7.4.1.1 Manipulator attached to the automatic EV supply equipment

The vehicle inlet shall be located within the mating space before the vehicle requests for mating.

No vehicle parts shall be located within the package space when the vehicle requests for mating until undocking is finished.

7.4.1.2 Manipulator attached to the vehicle

See [7.3](#).

NOTE See sequence diagrams in IEC TS 61851-26 and IEC TS 61851-27 for more information about mating request.

7.4.2 Package space dimensions

IEC 62196-2, IEC 62196-3 and IEC TS 63379 specify a package space intended for manual mating of the vehicle connector.

For vehicle inlets, where a specific package space intended for docking and undocking is not specified in the product standard of the vehicle inlet, see IEC TS 61851-26 and IEC TS 61851-27 for information.

NOTE IEC 62196-2, IEC 62196-3 and IEC TS 63379 do not use the specific term “package space”.

7.5 Manual undocking

The vehicle shall allow a procedure for manual undocking of the manipulator and the attached accessory (plug or vehicle connector), which can be operated in any of the following cases:

- loss of power supply of the automatic EV supply equipment;
- failure of the automatic EV supply equipment;
- failure of the automatic undocking function of the vehicle.

The EV shall provide manual operation for components (e.g. manipulator or covers) that can cause a hazard while driving if automatic connection fails. This manual operation shall allow the user to manually put the EV to a safe state.

Instructions shall be given in the manual.

7.6 ACD operation process and communication

According to IEC TS 61851-26 and IEC TS 61851-27 the ACD operation process is modelled as an ACD session, which is organized by a sequence of activities. These activities are executed respectively supported by communication between the EVCC and the SECC, but also imply additional hardware requirements for

components of a vehicle beyond the specifications in this document. The requirements for a vehicle related to the execution of the activities are described in IEC TS 61851-26 and IEC TS 61851-27.

NOTE The sequence descriptions in IEC TS 61851-26 and IEC TS 61851-27 also cover requirements to verify compatibility as well as requirements related to the readiness of the inlet or socket-outlet for mating, which includes cover operations.

7.7 Mechanical operational requirements

7.7.1 Mounting position of the vehicle inlet

The vehicle inlet shall be mounted in a position that can be reached by the manipulator of the automatic EV supply equipment.

The manipulator of the automatic EV supply equipment can reach only vehicle inlets which are positioned within the mating space as specified in IEC TS 61851-26 or IEC TS 61851-27.

7.7.2 Movement/displacement of immobilized vehicle

7.7.2.1 Movement/displacement of immobilized vehicle with the manipulator attached to the automatic EV supply equipment

The movement/displacement of the vehicle inlet of an immobilized vehicle shall not exceed the values of [Table 2](#) under normal operating conditions.

NOTE 1 Automatic EV supply equipment according to IEC TS 61851-26 and IEC TS 61851-27 consider these movements/displacements during mating, unmating and during power transfer. In addition, measures related to movements outside the values given in [Table 2](#) are in the responsibility of the manufacturer of the automatic EV supply equipment.

NOTE 2 Requirements related to immobilization within the sequence of the ACD operation process are given in IEC TS 61851-26 and IEC TS 61851-27.

Table 2 — Movement of vehicle inlet of passenger cars

Parameter	Value	Remarks
ΔX	± 20 mm	Possible movement of vehicle while gearshift in "P"
ΔY	± 7 mm	
ΔZ	± 70 mm	Considering loading/unloading the vehicle the position of the inlet in z- direction can vary by 70 mm between the fully loaded and fully unloaded situation.
Δyaw	$\pm 1^\circ$	movement around z-axis
Δroll	$\pm 2^\circ$	movement around x-axis
Δpitch	$\pm 2^\circ$	movement around y-axis

The movements/displacements given in [Table 2](#) may occur simultaneously in different directions and angles.

X-, Y- and Z-direction in [Table 2](#) are in accordance with the directions of the axes in ISO 4130. The origin of rotation for the yaw, roll and pitch angle given in [Table 2](#) is the tip of the PE pin of the inlet.

NOTE 3 Movements/displacements in z-direction and the movements around the axes given in [Table 2](#) are included in the mating spaces in IEC TS 61851-26 and IEC TS 61851-27.

NOTE 4 Requirements for abnormal condition where the specifications for movement/displacement are exceeded, e.g. caused by a flat tire, crash or an earthquake, are under consideration and not covered in this document.

NOTE 5 See [Annex A](#) for inlet position and movement/displacement for heavy duty vehicles.

7.7.2.2 Movement/displacement of immobilized vehicle with the manipulator attached to the EV

The vehicle manufacturer shall specify the movement/displacement of the immobilized vehicle that is not exceeded under normal operating conditions.

This movement/displacement shall not cause:

- an interruption of power transfer; nor
- a damage to any part of the vehicle or the automatic EV supply equipment; or
- an unsafe situation;

during mating, unmating and power transfer (see [7.3](#)).

NOTE Requirements for abnormal condition where the specifications for movement/displacement are exceeded, e.g. caused by a crash or an earthquake, are under consideration and not covered in this document.

7.7.3 Forces during mating and unmating

The vehicle inlet shall resist the forces of the manipulator of the automatic EV supply equipment during mating as specified in IEC TS 61851-26 or IEC TS 61851-27.

8 Owner's manual and markings and instructions

The manual shall provide information about manual undocking, see [7.5](#).

9 Test procedure

Testing requirements are under consideration and not covered in this document.

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