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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



23H/528/CD

COMMITTEE DRAFT (CD)

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IEC SC 23H : PLUGS, SOCKET-OUTLETS AND COUPLERS FOR INDUSTRIAL AND SIMILAR APPLICATIONS, AND FOR ELECTRIC VEHICLES	
SECRETARIAT: France	SECRETARY: Mrs Anne Le Guennec
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 69	PROPOSED HORIZONTAL STANDARD: ☒ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	

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TITLE:
Conductive charging of electric vehicles - Contact interface for automated connection device (ACD)

NOTE FROM TC/SC OFFICERS:

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INTRODUCTION

The electrical interface for charging electrically propelled vehicles with plugs, socket-outlets, vehicle connectors and vehicle inlets is described in IEC 62196 series and IEC 61851-23. For heavier vehicles such as buses and trucks, requirements of short charging times with high energy present a problem of handling, and safety with hand-held connecting devices. For these high current charging applications, an automated connection device (ACD) is of interest.

An automated coupler consists out of a mobile assembly with electrical contacts, called ACD and fixed electrical contacts, called ACD counterpart. Automated couplers allow an unmanned connection of high-current contacts and signal/control contacts.

This document contains requirements for all type of ACDs. Its annexes describe specific implementations and specific requirements. This document is expected to be read in conjunction with IEC 61851-23-1:—¹.

¹ Under preparation. Stage at time of publication: IEC CDV 61851-23-1:2020.

CONDUCTIVE CHARGING OF ELECTRIC VEHICLES - CONTACT INTERFACE FOR AUTOMATED CONNECTION DEVICE (ACD)

Scope

This document is applicable to ACDs of standardized configuration, intended for use in electric vehicle conductive charging systems which incorporate control means, with rated operating voltage up to 1 500 V DC.

This document applies to high power DC interfaces intended for use in isolated conductive charging systems, for circuits specified in IEC 61851-23-1:—¹.

The ACDs covered by this document are used only in charging mode 4, according to IEC 61851-23-1:—¹, 3.1.201 Case D or 3.1.202 Case E.

This document describes the requirements for an ACD in regard of safety, function and testing. This document describes basic parameters that can be standardized for different ACDs. ACDs following these standardized parameters will have the benefit of being compatible, even if they are based on different technologies.

This document does not apply to solutions based on a vehicle connector described in IEC 62196-3 and IEC TS63379 driven by an automated mechanism, as, for instance, a robotic arm.

This document does not cover all safety aspects related to maintenance.

This International Standard / This part of IEC XXXXX specifies / establishes / ...

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.

EN 1652, *Copper and copper alloys - Plate, sheet, strip and circles for general purposes*

EN 12163, *Copper and copper alloys - Rod for general purposes*

EN 12167, *Copper and copper alloys - Profiles and bars for general purposes*

EN 16005, *Power operated pedestrian door sets – Safety in use – Requirements and test methods*

IEC 62497-1, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*

IEC 60068-2-11, *Environmental testing - Part 2: Tests - Test Ka: Salt mist*

IEC 60204-1: 2016, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60309-1, *Plugs, fixed or portable socket-outlets and appliance inlets for industrial purposes – Part 1: General requirements*

IEC 60512-2-2, *Connectors for electronic equipment - Tests and measurements – Part 2-2: Electrical continuity and contact resistance tests - Test 2b: Contact resistance – Specified test current method*

IEC 60512-5-1, *Connectors for electronic equipment - Tests and measurements - Part 5-1: Current-carrying capacity tests - Test 5a: Temperature rise (IEC 60512-5-1)*

IEC 60512-5-2, *Connectors for electronic equipment - Tests and measurements - Part 5-2: Current-carrying capacity tests - Test 5b: Current-temperature derating (IEC 60512-5-2)*

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

IEC 61851-1:2019, *Electric vehicle conductive charging system - Part 1: General requirements*

IEC 61984:2008, *Connectors - Safety requirements and tests*

IEC 61851-23-1:—,² *Electric vehicle conductive charging system – Part 23-1: DC charging with an automated connection system*

IEC 62196-1:2014, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 1: General requirements*

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

IEC 62477-1:2016, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

IEC TS 63379, *Plugs, socket-outlets, vehicle connectors and vehicle inlets – conductive charging of electric vehicles - Vehicle connector, vehicle inlet and cable assembly for Megawatt DC charging—2*

Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61851-23-1:—¹ and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

working position

position reached when the ACD and the fixed ACD counterpart have mated and when the physical contact is established, and energy transfer is allowed

3.2

home position

position where the ACD is not engaged with its counterpart and where safe clearance is present with street and infrastructure

3.3

keep-out zone

Space around automated coupler, where no items shall be installed to avoid collision with any moving part of the ACD or ACD counterpart.

¹ Under preparation. Stage at time of publication: IEC CDV 61851-23-1:2020.

² Under preparation.

Electrical requirements

4.1 Voltage and current requirements

4.1.1 Number of contacts

For systems described in IEC 61851-23-1:—¹, Annexes AA, BB and CC:

Four contacts: DC+, DC-, PE and CP (IEC 61851-23-1:—¹, Figure AA.1, IEC 61851-23-1:—¹, Figure BB.1 and IEC 61851-23-1:—¹, Figure CC.14)

For systems described in IEC 61851-23-1:—¹, Annex KK:

three contacts: DC+, DC-, PE (IEC 61851-23-1:—¹, Figure KK.14)

4.1.2 Quality of DC charging voltage

Since the ACD is part of the power transmitting system, its influence on the quality of DC charging voltage shall be considered, to not exceed the levels indicated in IEC 61851-23-1:—¹.

4.1.3 Rated continuous current

The maximum current may exceed the limits defined in IEC 62196-1. The rated current can be a continuous current or the average of an intermittent current.

The rated current is defined by the vehicle and the application. The manufacturer of the ACD shall guarantee that his system is sized and safe for this current by confirming the physical values described in this document.

In the case of an automated coupler consisting of an ACD and an ACD counterpart from different or unknown manufacturers, the minimum current requirements that fulfil the requirements for a particular annex of this document shall be assumed unless there are sensing devices that can reliably determine if the ACD is operating within the defined limits of this document. However, if the ACD and the ACD counterpart can be definitively determined to be of a particular type and manufacturer, higher currents with or without sensing devices can be used, according to manufacturer's specifications.

4.1.4 Short-circuit current

In case of short circuit, the ACD shall not cause dangerous situation such as an explosion or a fire. After such a short circuit, the ACD shall be checked for proper function prior further service.

As ISO 5474-3: leaves the short-circuit value for systems with an automated coupler open, an automatic coupler shall be designed that way that it withstands a short-circuit with a Joule integral of 12 000 000 A²s.

NOTE 12 000 000 A²s can be reached with 34 600 A in 10 ms or 11 000 A in 100 ms or 3 460 A in 1 s.

The ACD shall be designed in such a way that a possible peak current of 70 kA (within the constraints of the 12.000.000 A²s energy mentioned above), considered in ISO 5474-3, 13.2.2.3 shall not lead to damages or dangerous situations in regard of the Lorentz force etc. If the physical design of the automated coupler limits the short current pulse to a lower value due to internal impedance of the automated coupler, the automated coupler shall be considered to this lower value.

4.1.5 Maximum temperature of contacts

The contacts of the automated coupler have a temperature rise depending on the charging current (rated continuous current or intermitted current). This temperature rise shall be considered by the system integrator, so that it has no damaging influence on materials or devices in the surrounding of the automated coupler at vehicle side and infrastructure side.

The ACD manufacturer shall indicate this maximum temperature rise in his documentation.

Compliance is checked by test in Clause 8, Table 3.

4.2 Signals

The minimum signals required are the status (the position) of the ACD. All other signalling necessary for pairing or charging are described in IEC 61851-23-1:—¹ or in ISO 15118.

Signal 1: ACD is in home position

Signal 2: ACD has reached working position (see annexes for specific implementation).

The home position signal is safety relevant.

There shall be a timeout if ACD is moved but the working position has not been reached in a specific time frame. This information shall be verified by overall system electric vehicle (EV) EVSE, not by the ACD.

Safety requirements

Relevant safety requirements in regard of the system are given by the IEC 61851-23-1.

5.1 Malfunction by contaminants

In case of blocking contaminants, the ACD might not reach the home position. There shall be an installed system that monitors the ACD to reach the home position. This shall be realized by the ACD itself and communicated to the overall system (EV or EVSE).

NOTE For reaction of this missing home position signal, refer to IEC 61851-23-1:—¹, CC.5.201, KK.5.201 or ISO 5474-5:7.6.5.

5.2 Contact sequence

According to IEC 61851-23-1:—¹, the connection and disconnection of the ACD shall be done without current. It is not necessary to have a contact sequence because no dangerous voltage is present.

NOTE Under fault emergency disconnection situation during power transfer without a first disconnecting CP or PE, arcing cannot be avoided. It is recommended to have a first disconnecting CP/PE or a guaranteed arc resistive system, so that no danger situation due to that arc can occur (f. e. fire). Scope is safety and not contact degradation.

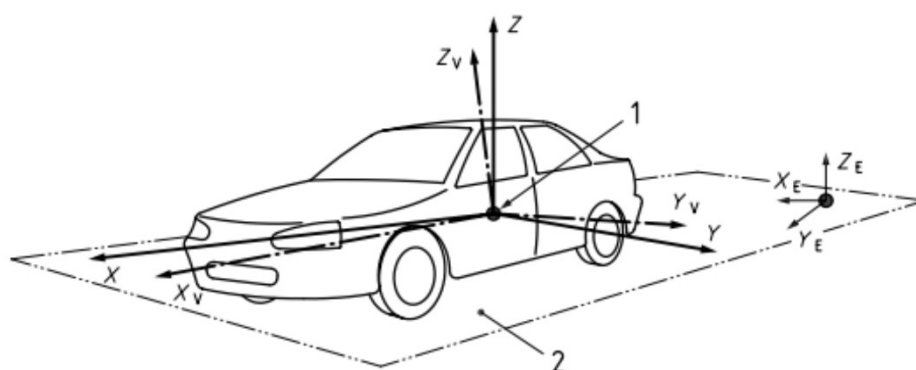
5.3 Return to home position

In case of an intentional or unintentional loss of supply power for the actuator of the ACD, the ACD shall return to its home position. For details refer to IEC 61851-23-1:—¹, Clause 201.3 “Loss of power”

Compliance is checked by test in Clause 8, Table 1 Test Number B3.

Mechanical requirements

6.1 Grid of parallels and meridians



Key

No	Part
1	Reference point – axle A as explained in 6.2

2 Ground level

Figure 1 — Grid of parallels and meridians according to ISO 8855**6.2 Specific mechanical requirements for busses**

Distinction shall be made with regards to the several vehicle dimensions, for instance double/single deck busses, resulting in several distances between the ACD and the ACD counterpart.

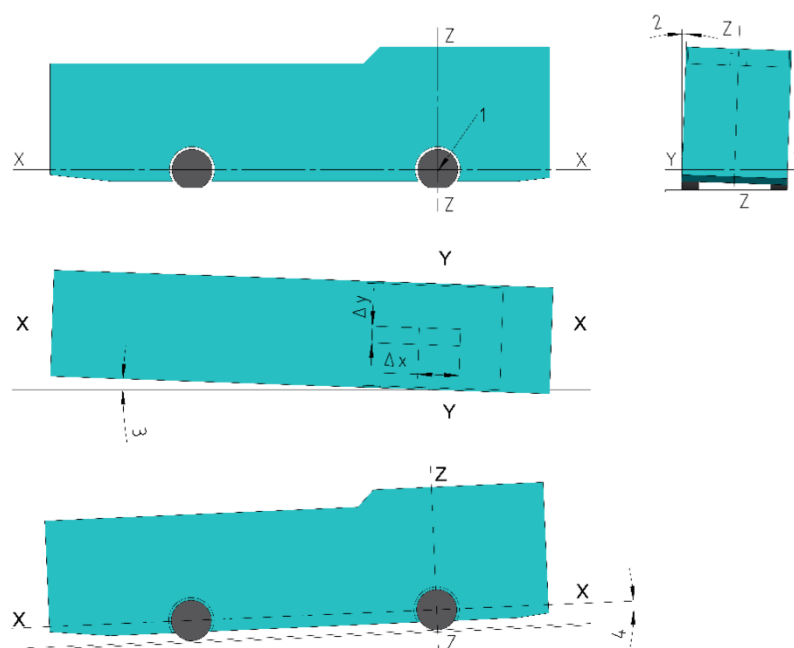
For the position of ACD or the ACD counterpart on the vehicle the reference point is centred over axle A.

Axle A is defined as the first front axle in regard of the driving direction of the vehicle.

This is the reference point for the parking tolerances during charging: x-centre, y-centre, z-centre of axle A

6.3 Tolerances of parking position**6.3.1 General**

Figure 2 shows the location of contact systems and positioning tolerances.

**Key**

No	Part
1	Axle A
2	ΦZ
3	ΦX
4	ΦSlope

Figure 2 — Location of a Contact System and Positioning Tolerances

6.3.2 Minimum normative requirement for parking

The minimal positioning tolerances that have to be compensated while positioning the vehicle for charging, are in X- and Y- directions and, for positioning angle, between vehicle and curb:

X at least ± 200 mm (Δx)

Y at least ± 200 mm (Δy), Y at least 0 to + 200 mm for **Annex C**

Angle between vehicle and curb (Φx) up to $\pm 2^\circ$

Being connected and the vehicle being immobilized, the ACD shall also deal with tolerances of the vehicle caused by dynamic movements, f. i. due to kneeling, wind, passenger on and off, etc., and has to avoid losing contact.

If any of above required tolerances are exceeded in service by accident, no dangerous or damaging situation shall occur. This can be done by physical limits, as for instance, curbs or sensors detecting the right position.

NOTE 1 Considering his requirements, the operator can require increased tolerance values if necessary.

NOTE 2 Besides public bus transports and specifically for autonomous vehicle or autonomous vehicle parking, e.g. automated driven bus depots, smaller tolerances can be agreed between contracting parties.

The physical dimensions of the ACD shall be considered for the dimensions of the vehicle and national or city regulations for minimum clearance in street traffic. A total load inclusive the force of the contact pressure shall be considered for the fixing points.

Environmental requirements

7.1 Degree of pollution

ACD which are IPXXB when mated shall be designed for pollution degree 3 according to IEC 62477-1:2016

ACD which are IP00 when mated shall be designed for pollution degree PD4 according to railway standard IEC 62497-1.

For covered or cleaned contacts, the normative described reduction of the creepage and air gap distance can be used.

NOTE Special pollutions such as leaves, branches etc. can be present and require regular cleaning of the interface. The cleaning schedule of the automated coupler can be agreed between the operator and the manufacturer of the ACD as its operation is highly dependent on the rate of pollution.

7.2 Overvoltage category

The over voltage category for the ACD shall be equal or higher than required in IEC 61851-23-1:—¹ and in ISO 5474-3: 6.2.6 Insulation coordination.

According to IEC 61851-23-1:—¹, **Clause 12.7.101** Suppression of overvoltage (insulation coordination), the DC EV charging station shall reduce overvoltage between DC $\pm$ and protective conductor to 2 500 V.

NOTE This document applies to EN IEC 61851-1 in regard of altitudes up to 2 000 m.

7.3 Ambient or operation temperature

According to IEC 61851-1:2017 ED.3, **Clause 5.2**, an ambient temperature of $-25/+40$ °C shall be considered.

NOTE In some countries, other requirements could apply, for example in the US the standardized ambient temperatures are -40 to $+50$ °C during operation.

Consideration shall be given that due to continuous intense sunshine, the surface of the bus could get hotter and this can have an impact to the ACD.

7.4 Noise

Noise in regard of the ACD can be emitted by moving the ACD from or to home position, in the connecting moment and also when vehicle is driving by wind effects. Existing national or local requirements shall be taken into consideration.

EXAMPLE The "TA Laerm" in Germany.

7.5 Wind

The defined parking and contact tolerances shall also apply under the influence of wind forces. Wind forces have an impact on the vehicle and on the station, in detail for example the support of the ACD. The manufacturer of the ACD shall provide a datasheet that identifies the forces on the mounting interface of the ACD and the contact forces in dependence of wind speed. In addition to that, also the worst-case displacement by wind within the working range of the ACD shall be in that datasheet.

The responsibility of safe operation under all wind circumstances shall lie at the system integrator.

Test specification and procedure

The following Tables 1 to 6 contain required tests for type testing and Routine Testing. The tables show testing standards and requirements for testing automated coupler. These tests are under respect to cover both cases, that automated coupler are from the same or from different manufacturers.

Critical system limits are characterized by current capacity testing, ensuring the system stays within its temperature limits and the system sustainability. Before doing the contact quality tests, Table 4 and following, during heat run test in Table 3 has to verify the system limits for temperature, contact resistance and contact voltage drop. These limits shall be used for the following tests.

An ACD shall be tested with a standardized fixed ACD counterpart that is defined in the appropriate annex. A fixed ACD counterpart shall be tested with a standardized ACD that is defined in the appropriate annex.

These tests are valid for all systems described in all annexes. If there are system specific tests or requirements they are described in the respective annex.

Table 1 — Dimensional inspections

Test N°	Test Name	Description / Measurements to be performed / Requirements	Type Test	Routine Test
A1	Visual Inspection	System complete to drawing and structure	X	X
A2	Weighing	Mass of assembled ACD shall be within tolerance limits of the specification	X	
A3	Functional Dimensions	General functional dimensions, described in the respective annexes, should be checked: - contact arrangement and dimensions - keep-out zone Dimensions shall be within the tolerances specified in the annex	X	
A4	Limited dimensions in home position		X	X
A5	complete working and moving range maximum extension		X	X
A6	arrangement and dimensions of all mounting points	checking the complete mounting interface to support	X	X
A7	Identification	manufacturer's name -ACD serial number -manufacturer's part number of ACD -nominal Voltage -rated current (see reference IEC 60204-1:2016)	X	X

Table 2 — Mechanical movement and operating tests

Test Number	Test Name	Description / Measurements to be performed / Requirements	Type Test	Routine Test
B1	Smoothness of contacting by ACD movement under minimal, nominal and maximal actuator power range. Note: Minimal, nominal and maximum actuator power range are considered between ACD manufacturer and system integrator.	Check for unblocked functioning	X	X
B2	Tightening torques of the cable connections	tested connection shall be marked or striped The integrity of the connection markings must be checked."		X
B3	Functional Test of returning to home position in case of intentional or unintentional power loss	IEC 61851-23-1:— ¹ , 201.3 Loss of power	X	X
B4	Nominal Static Force Test at minimal, nominal and maximal auxiliary power range (electric or pneumatic or ...)	This test is to be done with a complete ACD including a standardized counterpart. Refer to each annex for specific values		X
B5	Time for moving to maximum working value Time for moving to maximum working value under minimal, nominal, and maximal auxiliary power range (electric or pneumatic or ...)	Time measured to match data sheet	X	
B6	Time for moving from maximum working value to home position under minimal, nominal, and maximal auxiliary power range (electric or pneumatic or ...)"	Time measured to match data sheet	X	
B7	Function test of the heating system (ON / OFF-Function)	(optional if heating system integrated)	X	X
B8	Function test of the position switches, limiting switch or sensor under minimal, nominal, and maximal supply voltage range		X	X
B9	Function check of the actuator at nominal rated auxiliary energy (electric or pneumatic or ...) minimal, nominal, and maximal auxiliary power range (electric or pneumatic or ...)		X	X
B10	Tightening torques of the cable connections after all tests of mechanical movement and operating functions.	The integrity of the connection markings must be checked.	X	X

Table 3 — Current Carrying Capacity Tests / Heating Tests (Type Test)

Test Phase	Test Name	Standard for Testing	Description Measurements to be performed	Requirements
C1	Heating Test (by current)	IEC 60512-5-1 Connectors for electronic equipment - Tests and measurements - Part 5-1: Current-carrying capacity tests - Test 5a: Temperature rise The current shall be maintained until thermal stability is achieved. This is defined as when three consecutive measurements of temperature rise, taken at 5 min intervals, do not differ by more than 2 K. The current shall be maintained for a period of 1 h after stability is reached. The ambient temperature shall be recorded during the test.	Definition "rated current": current value assigned by the manufacturer, which the connector can carry continuously (without interruption) and simultaneously through all its contacts wired with the largest specified conductor, preferably at an ambient temperature of 40 °C, without the upper limiting temperature being exceeded. If other ambient temperature values are used for the definition of the rated current, the manufacturer should state, in the technical documentation, the ambient temperature on which the rating is based, with reference, if appropriate, to the derating curve defined in EN 60512-5-2 Test 5b.	With this test, the rated current of the device is determined (as noted in 4.1.3 Rated continuous current). Also to be considered: 4.1.5. Maximum temperature of contacts and 7.3. According to IEC 61851-1:2017 ED3, Clause 5.2, an ambient temperature of -25/+40 °C shall be considered. NOTE In some countries, other requirements could apply, for example in the US the standardized ambient temperatures are -40 to +50 °C during operation. Test acceptance criteria: The temperature of the contacts, power cables, etc shall not exceed the defined values in the material specification.
C2	Contact Resistance Test Power Contacts	IEC 60512-2-2	Contact resistance at rated current. The contact resistance shall be derived from the voltage drop measured at rated current between the zones intended for connection of the wiring	The voltage drop value criteria is valid for any rated current. For the type test value of the electrical contact resistance, the voltage drop at rated current shall be taken. For measuring the initial and final contact resistance in mechanical/thermal/environmental/chemical test sequences, practical wise it can be measured at common test currents of Multi-Meters, observing the value's relative change.

Table 4 — Mechanical Endurance Type Test

Test N°	Test Name	Standard for Testing	Description / Measurements to be performed / Requirements	Type Test
D1	Contact Resistance Test Power Contacts Initial test	IEC 60512-2-2	Contact resistance The contact resistance shall be derived from the voltage drop measured between the zones intended for connection of the wiring For practical reasons, the electrical contact resistance of a system can be measured at standard test currents with an appropriate Multi-Meters.	X
D2	Endurance Test Mating Cycles		Mating cycles: connecting and disconnecting over full working range, with no electrical current and nominal specified conditions. A minimum of 60.000 cycles for a vehicle mounted ACD coupler and 120.000 cycles for an infrastructure mounted ACD is required without any maintenance	X

			during the test. The pass criteria are no loss of functionality, no danger situation and all specifications are met. For depot installation with typical average of less than 5 cycles a day the ACD shall withstand minimum of 15.000 cycles without maintenance during the test.	
D3	Contact Resistance Test Power Contacts Final test	IEC 60512-2-2	Contact resistance The contact resistance shall be derived from the voltage drop measured between the zones intended for connection of the wiring The voltage drop at the contact shall not be higher than a 50 % raise with respect to the initial value measured under D1. For practical reasons, the electrical contact resistance of a system can be measured at standard test currents with appropriate Multi-Meters.	X
D4	Function test of the position switches, limiting switch or sensor under minimal, nominal, and maximal supply voltage range.			
D5	Vibration Test		Not to be specified on component level here	
D6	Mechanical Shock Test		Not to be specified on component level here	
D7	Tightening torques of the cable connections after all tests of mechanical movement and operating functions		The integrity of the connection markings must be checked.	

Table 5 — Electrical Tests

Test N°	Test Name	Standard for Testing	Description / Measurements to be performed / Requirements	Type Test	Routine Test
E1	Insulation Resistance Test	IEC 60309-1:2021, 19.2	19.2 The insulation resistance is measured with a DC voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage. Insulation Resistance: shall be measured between all phases, and between all phases versus ground for 60s. The insulation resistance shall be not less than 5 MΩ Alternatively, refer to EN IEC 61851-1:2019, 12.5. for the complete system	X	X
E2	Reliability of the PE Contact	IEC 61984:2008 6.5.3 7.3.13	6.5.3 Reliability of connection to PE contacts 7.3.13 Resistance between accessible metal parts and the protective earthing contact 25 A is passed through the contact and each of the accessible metal parts in sequence. Resistance shall not exceed 0,1 Ω	X	X
E3	Short-Circuit Current Test	Test procedure see IEC 62196-1:2014, 31.2	A short-circuit test shall be applied to the automated coupler to verify the safe behaviour of the arrangement. The values of the short current is mentioned in 4.1.4. The worst case scenario has to be considered, which is a short on DC+ and DC- on the EVSE side of the automated coupler, sourced from the EV side with maximum current pulse defined in 4.1.4. If the physical design of the automated coupler limits the short current pulse to a lower value as defined in 4.1.4 due to internal impedance of the automated coupler although the testing source is	X	

Test N°	Test Name	Standard for Testing	Description / Measurements to be performed / Requirements	Type Test	Routine Test
			able for the required short circuit current pulse the test may be done with this lower value.		

Table 6 — Salt Spray Test (Type Test)

Test Phase	Test Name	Standard for Testing	Description Measurements to be performed	Requirements
F1	Initial Test Contact Resistance (Power Contacts)	IEC 60512-2-2	Contact resistance The contact resistance shall be derived from the voltage drop measured between the zones intended for connection of the wiring	Visual inspection. Functionality of the parts
F2	Salt Spray Test	IEC 60068-2-11 Test Ka	During a period of 672 h. Measurements made after 168 h, 336 h and 504 h. (Visual inspection and insulation resistance measurement). After testing, the parts will be rinsed with distilled water and dried. Sanctions: After the test, the specimens will be examined visually. Special attention will be brought to the examination of the tension spring.	Test Sequence: F1 4 days F3 1 week F3 2 weeks F3 4 weeks F3
F3	Final Test Contact Resistance Test Power Contacts	IEC 60512-2-2	Contact resistance The contact resistance shall be derived from the voltage drop measured between the zones intended for connection of the wiring The voltage drop value criteria is valid for any rated current. For practical reasons, the electrical contact resistance of a system can be measured at standard test currents with appropriate Multi-Meters.	Visual inspection. Functionality of the parts The voltage drop at the contact shall not be higher than a 50 % raise with respect to the initial value measured at F1.

Documentation

There shall be a documentation being handed over from the manufacturer to the operator. In this documentation the maintenance cycles for visual inspection are mandatory. This visual inspection should discover damages in regard of arcing, wear, and proper operation.

Annex A

(normative)

ACD mounted on the infrastructure - ACD counterpart on the roof of the vehicle

A.1 Generals of infrastructure mounted ACD function

The mobile assembly ACD mounted on the infrastructure is one type of ACD that transfers power between the infrastructure and the vehicle (refer to case D connection IEC 61851-23-1:—¹).

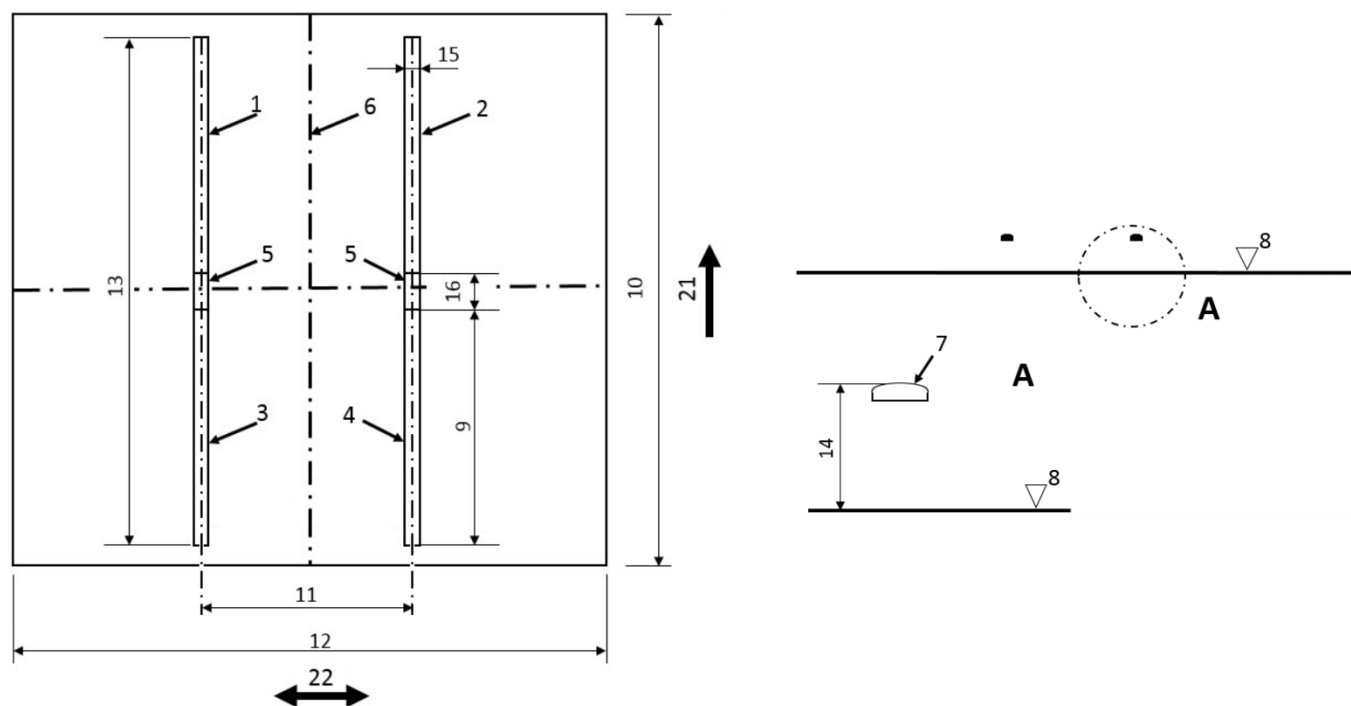
- Active/ ACD shall be mounted in the infrastructure and
- Active/ ACD shall be equipped with a collector head with 4 contacts and
- Active/ ACD shall move mainly vertically between home and working positions and
- Active/ ACD contactor stripes shall contact mainly perpendicularly with the fixed ACD counterpart/passive part contact stripes and
- ACD counterpart/passive part shall be mounted on the roof of the bus, called roof rails and
- ACD counterpart/passive part shall have 4 contact rails.

A.2 ACD mounted on the infrastructure – ACD counterpart on the roof of the vehicle with two in-line and two parallel contact bars

A.2.1 ACD counterpart mechanical arrangement

- Four poles: DC+, DC-, Protective Earth (PE), Control Pilot (CP) and
 - The poles DC+ and DC- are arranged diagonal to each other (see Figure A.1) and
 - The poles PE and CP are arranged diagonal to each other (see Figure A.1) and
 - Dimensions for the rails shall be as follows (see Figure A.1):
 - Length of the roof rails in X direction shall be according to Figure A.1,
 - Length of each contact rail in x direction shall be according to Figure A.1,
 - Width in y direction (space between the middle of the contact surface) shall be according to Figure A.1.
- and
- Minimum space needed on the roof shall be as follows (see Figure A.1):
 - Length in X direction (driving direction) shall be according to Figure A.1

- Width in Y direction (vertical to driving direction) shall be according to Figure A.1,
- Distance between contact rails in one line (DC+ and PE, DC- and CP)) shall be according to Figure A.1.
- Air distance between live parts and any other side surface shall be according to Figure A.1. This is just a functional distance and no insulation requirement.
- The contact surface of the roof rails shall be rounded with radius according Figure A.2 and
- The cross-sectional area of the contact rails and contact strips should meet the acceptance criteria of the special type test by using a gauge for the contact strips of the ACD according to Figure A.8 and
- The contacts shall be made of copper or copper alloy which shall be coated against corrosion.
- Optional heating system for de-icing the contacts.

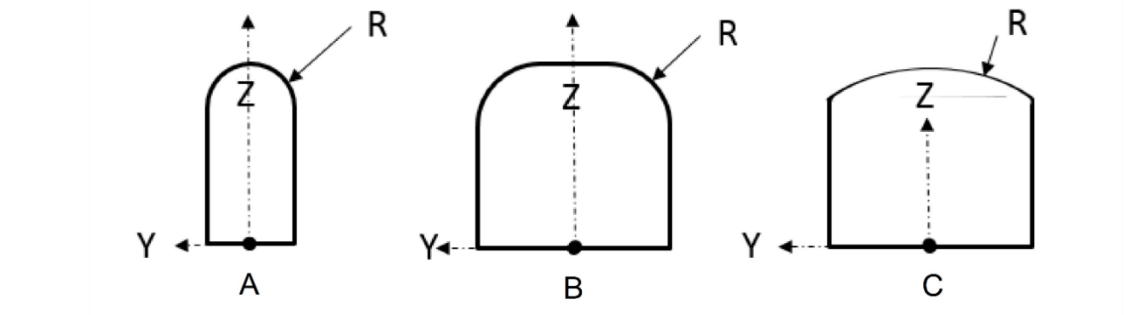


Key

No	Description
1	CP
2	DC+
3	DC-
4	PE
5	Insulator
6	centre line of vehicle
7	rounded surface
8	Vehicle mounting plane
21	x-direction (driving direction)
22	y-direction (perpendicular to driving direction)

No	Description	value	tolerance
		mm	mm
9	Length of each contact rail	650	0 / + 4
10	Minimum length in X direction	1 500	
11	space between the middle of the contact surface (centre line to centre line)	670	± 2
12	Minimum width in Y direction	2 200	
13	Length of the roof rails	1 400	+9/-1
14	height of upper surface of roof rails above assembly area	≥ 80	
15	Width of roof rails	≤ 60	
16	Distance between contact rails	100	± 1

Figure A.1 — Mechanical arrangement of counter part

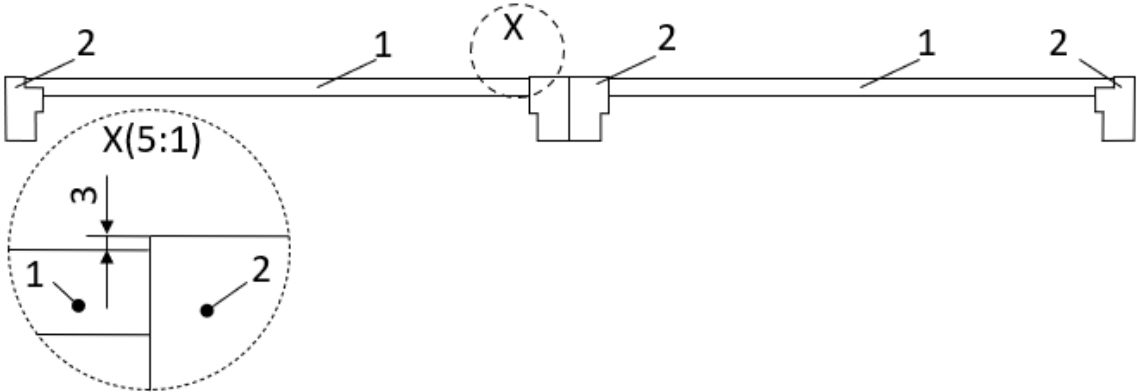


Key

No	Description	No	Description	value
				mm
A	Shape A	R	radius R of rounded contact surface of the roof rails	$4 \leq R \leq 100$
B	Shape B			
C	Shape C			

Figure A.2 — Principal proposal roof rail shapes with rounded surfaces

The surface of the roof rails shall be in horizontal line with insulated support as much as possible.
A maximum vertical exaggeration of the support above the roof rails is defined in figure A.3 no. 3.
The ACD counterpart design shall be avoid that the ACD rails to get caught to the support of the roof rails.



F

Key

No	Description	value
		mm
VTD	Principle view top down	-
1	Roof rails (Poles: PE or CP or DC+ or DC-)	-
2	Insulated support	-
3	Maximum vertical exaggeration of support above contact rails	6

Figure A.3 example of a principle design of roof rails and accepted vertical exaggeration of the supports

A.2.2 Keep-out zone

The keep-out zone marks the space where nothing shall be placed in, neither on the vehicle nor in the infrastructure. The values given in the Figures A.4 and A.5 are absolute minimum values.