

Combined Charging System Definition and Scope

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Abbreviations

| | |
|--------|--|
| AC | Alternating current |
| AC BS | Alternating current Basic Signaling |
| AC HLC | Alternating current High Level Communication |
| AWI | Approved Work Item |
| BS | Basic Signaling |
| CCS | Combined Charging System |
| CDV | Committee Draft on Voting |
| CP | Control Pilot |
| DC | Direct current |
| DC HLC | Direct current High Level Communication |
| DIN | German Institute for Standardization |
| SPEC | Specification |
| DIS | Draft International Standard |
| Ed | Edition |
| EIM | External Identification Means (External payment) |
| EV | Electric Vehicle |
| EVSE | Electric Vehicle Supply Equipment |
| FDIS | Final Draft International Standard |
| HLC | High Level Communication |
| IC-CPD | In-cable Control Protection Device |
| IEC | International Electrotechnical Commission |
| ISO | International Organization for Standardization |
| OEM | Original Equipment Manufacturer, here automotive manufacturers |
| PE | Protective Earth |
| PnC | Plug and Charge |
| PLC | Power Line Communication |
| PWM | Pulse Width Modulation |
| RCD | Residual Current Device |
| RFID | Radio Frequency Identification |
| TS | Technical Specification |
| US | United States of America |

1 Purpose of document

1.1 Overview

The members of the association have committed themselves to the use of CCS which allows AC-charging as well as DC-charging.

It contains a set of features which are described in several international and national standards. As standards usually evolve, a need is given to fix a set of features with the corresponding releases of standards as an Implementation Baseline for series production of EV and EVSE's.

This document

- defines the system for charging EVs named CCS,
- defines the set of features with reference to relevant standards as CCS Basic for the first generation of EV and EVSE's and
- gives an overview of the set of features with reference to relevant standards for CCS Extended.

For information on the relation of CCS Extended and CCS Basic see Clause 4.3.

2 Description of CCS

2.1 General

The Combined Charging System (CCS) is based on open and universal standards for electric vehicles. The CCS combines single-phase with rapid three-phase charging using alternating current at a maximum of 43 kilowatts (kW), as well as direct-current charging at a maximum of 350 kW and the future perspective of up to 450 kW – all in a single system.

The CCS includes the connector and inlet combination as well as all the control functions. It also manages communications between the electric vehicle and the infrastructure. As a result, it provides a solution to all necessary charging requirements.

The key features of the Combined Charging System include the following:

- AC charging:
 - With the electrical interface specification for power transmission, which includes safety-related signaling for AC charging that complies with the IEC 61851-1 standard.
 - With the Type 2 connector in Europe and the Type 1 connector in the US and Japan is compliant with the IEC 62196-2 standard.
- DC charging:
 - With the electrical interface specification for power transmission, which includes safety-related signaling for DC charging that complies with the international IEC 61851-23 standard.
 - With the Combo 2 connector in Europe, and the Combo 1 connector in the US and Japan compliant with the international IEC 62196-3 standard
- The communication interface between the electric vehicle and the charging point, based on the international standard ISO/IEC 15118 and the German DIN SPEC 70121.

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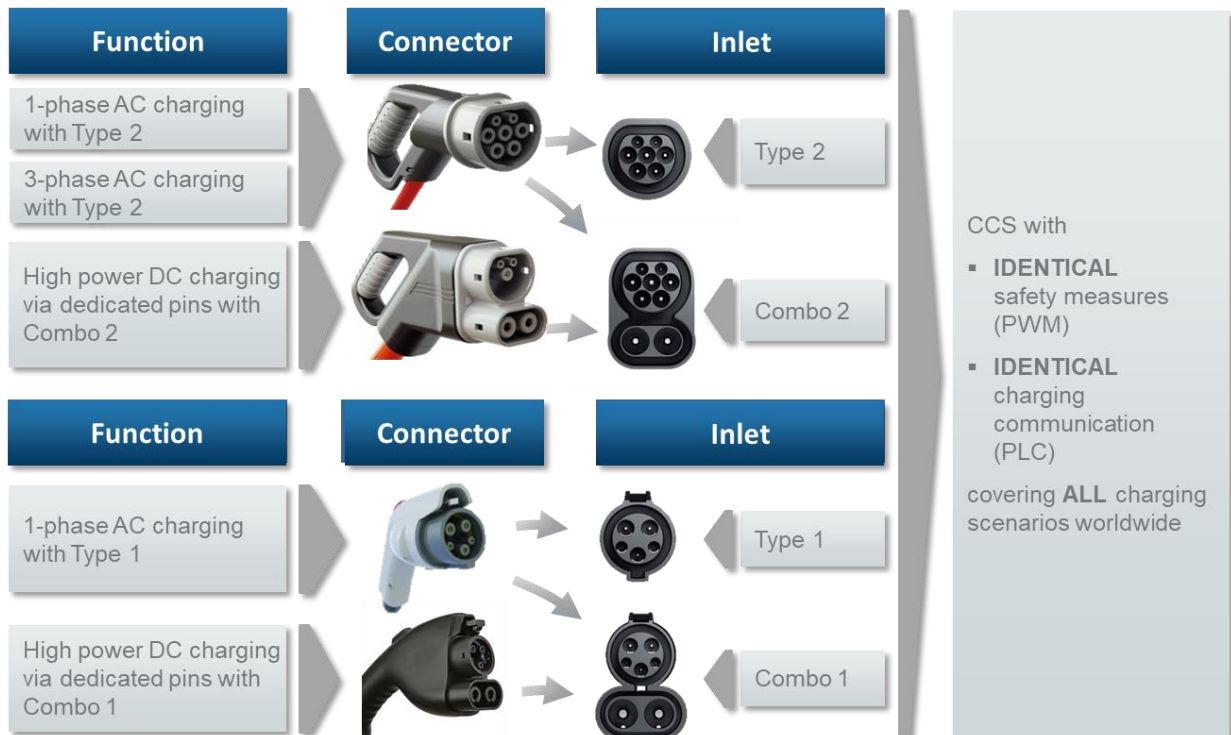


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Figure 1 – Charging Interface of CCS

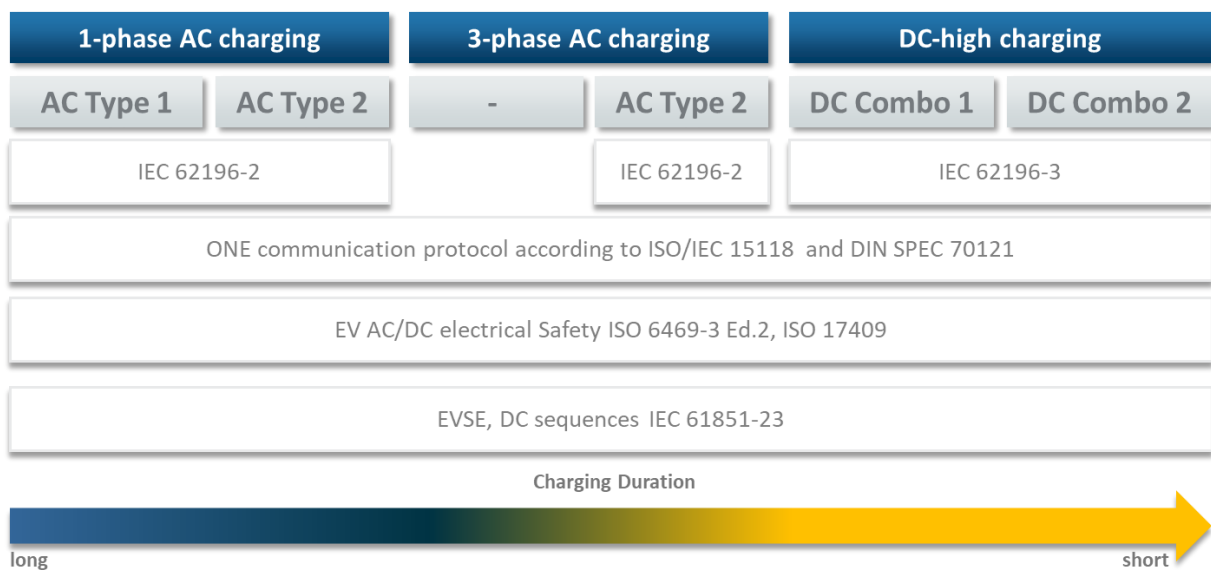


Figure 2 – Main standards for CCS

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The charge inlet features protective mechanisms for safe charging and is fitted with all the necessary pins for charging scenarios worldwide. A lock system prevents the connector from being accidentally pulled out of the inlet while charging. The charging process is controlled by special electrical signals from the moment the connector is connected to the inlet until the end of charging. The system also features digital communication via PLC between vehicle and charging station. This allows charging control for complex charging scenarios (e.g., load balancing) and is prepared for future demands.

The combined inlet of CCS is designed as a universal charging interface. The charge inlet for AC charging, as described in IEC 62196-2 has been Extended by two pins for DC charging to allow high power charging in a very short period of time.

CCS is therefore an integrated solution for AC- and DC-charging. EVs are “CCS-capable” if they support either

- AC charging with Type 1 (US) or Type 2 (Europe) Connector according to IEC 62196-2 or
- DC charging with Combo 1 (US) or Combo 2 (Europe) Connector in IEC 62196-3

The following Clauses describe the set of features of CCS to be named:

- Charging Type, see 2.2
- Charging Inlet, see 2.3
- Charging Mode, see 2.4
- Load Balancing, see 2.5
- Charge Authorization Mode, see 2.6
- Charging Safety, see 2.7

2.2 Charging Type

The following charging types are supported by the CCS: AC and/or DC.

For AC two charging control methods can be implemented:

- Basic signaling based on PWM
- High level communication based on PLC

For AC charging CCS supports one or both of the charging process control mechanisms.

For DC charging CCS supports only

- High Level Communication based on PLC

because it is needed to control the external DC charger.

Table 1 – Charging Process Control Methods

| | PWM | PLC |
|----|-----------|-----------|
| AC | mandatory | optional |
| DC | mandatory | mandatory |

The designation codes in Table 2 are used to name the features for Charging Type.

Table 2 – Designation Code for Charging Type

| Description | Designation Code |
|-----------------------------|------------------|
| AC Basic Signaling | AC BS |
| AC High Level Communication | AC HLC |
| DC High Level Communication | DC HLC |

2.3 Charging Connector and Inlet

For AC charging in Europe the CCS uses the Type 2 Inlet or the Combo 2 Inlet mated with the Type 2 Connector. For DC charging in Europe the CCS uses the Combo 2 Inlet mated with the Combo 2 Connector.

The designation codes in Table 3 are used to name the features for the Charging Connector and Inlet.

Table 3 – Designation Code for Charging Connector and Inlet

| Description | Designation Code |
|---------------------------|---------------------|
| Type 1/2 AC Inlet | Type 1/2 Inlet |
| Combo 1/2 AC and DC Inlet | Combo 1/2 Inlet |
| Type 1/2 AC Connector | Type 1/2 Connector |
| Combo 1/2 DC Connector | Combo 1/2 Connector |

2.4 Charging Mode

Four charging modes are defined. Modes 1 to 3 relates to charging with a charger unit installed in the vehicle (on-board charger), Mode 4 describes the use of an “off-board charger”.

Mode 1 is characterised as follows:

- AC charging at normal mains outlets
- no protection devices in the charging cable
- RCD in domestic installations an essential prerequisite

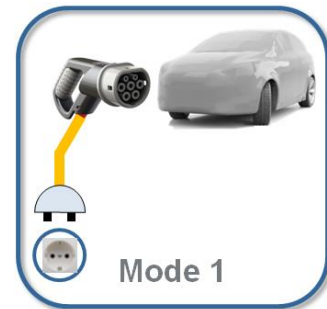


Figure 3a – Mode 1 Charging

Mode 2 is characterised as follows:

- AC charging at normal mains outlets
- charger cable with integrated safety devices in an in-cable control box comprising RCD, control pilot and proximity detection
- without energy feedback, signaling between the in-cable control box and the electric vehicle is mandatory via the control pilot

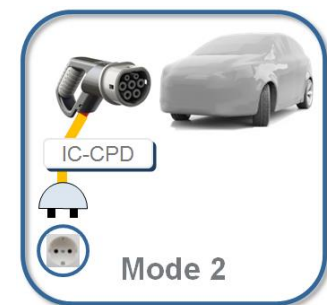


Figure 3b – Mode 2 Charging

Mode 3 is characterised as follows:

- AC charging at Type 1/2 charging stations
- safety equipment is a permanent part of the charging station, no in-cable control box required in the cable
- Type 2 plug interlock permits unsupervised operation, even in a public space



Figure 3c – Mode 3 Charging

Mode 4 is characterised as follows:

- DC charging at Combo 1 /2 charging stations
- Charging system can manage various charging currents and charging voltages to adopt various battery systems
- For charging control HLC is required




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Figure 3d – Mode 4 Charging

The designation codes in Table 4 are used to name the features for the Charging Modes.

Table 4 – Designation Code for Charging Modes

| Description | Designation Code |
|-----------------|------------------|
| Mode 1 Charging | Mode 1 |
| Mode 2 Charging | Mode 2 |
| Mode 3 Charging | Mode 3 |
| Mode 4 Charging | Mode 4 |

2.5 Load Balancing

CCS differentiates two methods for Load Balancing: Unscheduled and Scheduled.

Unscheduled is characterized as follows:

- The energy flow from the EVSE to the EV
- The EVSE can change the maximum current / power during the charging process

Scheduled is characterized as follows:

- Supports Reactive Load Balancing
- Additionally, the energy flow from the EVSE to the EV can planned with different power limits and cost indicators over time
- Scheduled Load Balancing allows to predict the behavior of charging process and optimize the energy distribution in a Smart Grid

The designation codes in Table 5 are used to name the features for the load balancing.

Table 5 – Designation Code for load balancing

| Description | Designation Code |
|--------------------------|------------------|
| Reactive load balancing | Reactive |
| Scheduled load balancing | Scheduled |

2.6 Charge Authorization Mode

CCS differentiates two methods for authorizing the charging: External Payment and Plug and Charge.

Plug and Charge is characterized as follows:

- Standardized Authorization where the user just has to plug their vehicle into the EVSE and all aspects of authentication and authorization are automatically taken care of with no further intervention from the user
- Plug and Charge is based on security mechanisms and certificates specified in ISO15118-2 for authentication and authorization
- This authorization can include free charging but allows to limit the authorized user to a predefined user group

External Identification Means is characterized as follows:

- Any mechanism not involving the EV, that authorizes a user for charging (e.g. RFID, QR code, Mobile App, credit card...)
- This is e.g. a RFID or cash payment unit mounted to a EVSE
- External Payment can also include free charging, e.g. applicable for free charging stations or a wallbox in a garage.

The designation codes in Table 6 are used to name the charge authorization modes.

Table 6 – Designation Code for Charge Authorization Mode

| Description | Designation Code |
|-------------------------------|------------------|
| External Identification Means | EIM |
| Plug and Charge | PnC |

2.7 Charging Safety

The Combined Charging System uses various safety measures to avoid

- Electric Shock,
- Fire
- Electric Arc and
- Overheating

under normal use including operation and non-operation mode. Table 7 gives an overview of some of the major safety measures. It does not claim completeness. For completeness and full description of requirements the relevant national and international standards shall be taken into account.

Table 7 – Overview on Safety Features

| Description | Relevant Standard |
|--|--|
| Protection against direct contact and De-energization of unmated connector | ISO 17409 IEC 61851-1 IEC 62196-3 |
| Basic insulation | IEC 61851-1 |
| Locking of Connector by vehicle in dc supply mode | ISO 17409 IEC 62196-3 IEC 61851-23 |
| Grounding, PE connection | IEC 60364-5-54 |
| Continuity of connection between station and vehicle | IEC 61851-1 IEC 61851-23 |
| Touch current limitation | IEC 61851-23 ISO 17409 |
| Aging /environmental conditions to apply for the Combined Charging System | IEC 61851-1 IEC 62196-1 |
| Adoption of measures from IT-systems | IEC 61851-23 |
| Voltage measurement at vehicle inlet in combination with disconnecting device (unintended connection of AC/DC) | ISO 17409 |
| DC Input resistance against damage due to AC voltage | ISO 17409 |
| Temperature monitoring of connector | IEC 61851-23 |
| De-energisation function of mated connector | ISO 17409 |
| Exit strategies based on specified control (Charge sequence, communication) | IEC 61851-23 |
| Prevention of unintended power supply from vehicle | IEC 61851-23 |
| Overvoltage Category at Vehicle Connector | IEC 61851-23 |
| NOTE: The overview on the Safety Features in Table 7 does not claim completeness. | |

3 CCS Basic

3.1 Set of features for CCS Basic

Figure 4 defines the features for the three main charging types AC BS, AC HLC and DC HLC which shall be used for the implementation of CCS Basic in EV and EVSE's. Safety Features described in 2.7 are implemented in CCS Basic.

Combinations between the three Charging Types are possible. The following (combinations) shall be supported for CCS Basic:

1. AC BS
2. AC BS + AC HLC
3. AC BS + DC HLC

Optional all three Charging Types for CCS Basic are possible: AC BS + AC HLC + DC HLC.

| Charging Type | CCS Basic | | |
|---------------------------|------------------------------------|------------------------------------|---------------------|
| | AC BS | AC HLC | DC HLC |
| Charging Connector | Type 1/2 Connector | Type 1/2 Connector | Combo 1/2 Connector |
| Charging Inlet | Type 1/2 Inlet or Combo 1/2 Inlet* | Type 1/2 Inlet or Combo 1/2 Inlet* | Combo 1/2 Inlet |
| Charging Mode | Mode 2 or 3 | Mode 2 or 3 | Mode 4 |
| Load Balancing | Unscheduled | Unscheduled and/or Scheduled | Unscheduled |
| Charge Authorization Mode | EIM | EIM and/or PnC | EIM |

* if DC HLC is supported


Figure 4 – Set of Features for the Combined Charging System Basic

3.2 Set of standards for CCS Basic

Figure 5 defines the relevant standards and specifications for the three main charging types AC BS, AC HLC and DC HLC for Charge Authorization Mode which shall be used for CCS Basic. Further standards and specification for CCS Basic see Annex A.

| | Specific standards for Charge Authorization Mode |
|------------------|--|
| CCS Basic AC BS | IEC 61851-1:2010 Ed 3.0 |
| CCS Basic AC HLC | IEC 61851-1:2010 Ed 3.0 ISO/IEC 15118-2: 2014 Ed. 1.0 ISO/IEC 15118-3:2015 Ed1 |
| CCS Basic DC HLC | DIN SPEC 70121:2014-12 |

Figure 5 –Set of standards for Authorization for the three main charging types for CCS Basic

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4 CCS Extended

4.1 Set of features for CCS Extended

Figure 6 gives an outlook on the expected features for AC BS, AC HLC and DC HLC in CCS Extended in comparison to CCS Basic. The features for Load Balancing and Charge Authorization Mode for DC HLC have been Extended for CCS Extended. Changes are underlined.

| Charging Type | CCS Extended | | |
|---------------------------|---------------------------------------|---------------------------------------|---|
| | AC BS | AC HLC | DC HLC |
| Charging Connector | Type 1/2 Connector | Type 1/2 Connector | Combo 1/2 Connector |
| Charging Inlet | Type 1/2 Inlet or Combo 1/2 Inlet* | Type 1/2 Inlet or Combo 1/2 Inlet* | Combo 1/2 Inlet |
| Charging Mode | Mode 2 or 3 | Mode 2 or 3 | Mode 4 |
| Load Balancing | Unscheduled | Unscheduled and/or Scheduled | Unscheduled <u>and/or</u> <u>Scheduled</u> |
| Charge Authorization Mode | EIM | EIM and/or PnC | EIM <u>and/or</u> <u>PnC</u> |
| * if DC HLC is supported | | | |

Figure 6 – Set of Standards for the three main charging types for CCS Extended

DC Minimum requirements for EV:

- Mandatory: Support of ISO15118 ed1 with EIM and TLS
 - o Optional: Renegotiation trigger (if power reduction is sufficient)
- Optional: Support of DIN (implementation recommended for interoperability with EVSE CCS1.0)


DC Minimum requirement for EVSE:

- Mandatory: Support of ISO15118 ed1 with EIM and TLS
 - o Optional: Renegotiation trigger
 - o SAScheduleList size : restricted to 1 with no tariff table
- Mandatory: Support of DIN SPEC 70121:2014

4.2 Set of standards for the CCS Extended

Figure 7 presents the standards for AC BS, AC HLC and DC HLC for Charge Authorization Mode in CCS Extended. Further standards and specification for CCS Extended see Annex B.

Expected changes for the set of standards for AC BS, AC HLC and DC HLC in comparison to CCS Basic are underlined.

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|---|---|
| Specific standards for Charge Authorization Mode | |
| CCS Extended AC BS | <u>IEC 61851-1 Ed 3.0</u> |
| CCS Extended AC HLC | <u>IEC 61851-1 Ed 3.0,</u> <u>ISO/IEC IS 15118-2:2014 Ed 1.0</u> <u>ISO/IEC IS 15118-3:2015 Ed 1.0</u> |
| CCS Extended DC HLC | <u>DIN SPEC 70121:2014-12</u> <u>ISO/IEC IS 15118-2:2014 Ed 1.0</u> <u>ISO/IEC IS 15118-3:2015 Ed 1.0</u> |

Figure 7 – Set of Standards for Authorization for the three main charging types for CCS Extended

CCS charging stations shall be compliant with the outlined required power and communication specified in the CharIN DC charging station power classes. https://www.charinev.org/fileadmin/Downloads/Papers_and_Regulations/CharIN_DC_CCS_Power_Classes_V6.pdf

CCS Extended vehicles and charging stations shall support ISO15118 External Identification Means (EIM) mandatory and Plug and Charge (PnC) optional

CCS Extended vehicles and charging stations shall be prepared to update from EIM to PnC (e.g. TLS and XML Certificates)

CCS Extended vehicles and charging stations shall support ISO15118 Plug and Charge (PnC) mandatory in 2020.

Charging Station shall provide its max. possible power in ChargeParameterDiscoveryRes message when ISO15118 communication is established. (not adapted to request from vehicle)

4.3 Expected set of standards for the CCS 3.0

In addition to the CCS Extended features CCS 3.0 will support

- Wireless communication,
- Inductive charging,
- Reverse Power Transfer and support for
- Electric Busses (e.g. Pantograph).

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CCS 3.0 will be based on

- ISO15118-2 Ed2
- ISO15118-3 Ed1
- ISO15118-8 Ed1
- IEC61851-1 Ed3

Appendix A Documents for the CCS Basic

The following documents shall be used for the implementation of CCS Basic.

ISO/IEC 15118-1:2013, *Road vehicles – Vehicle to grid communication interface - Part 1 – General information and use-case definition*

ISO/IEC 15118-2:2014, *Road vehicles – Vehicle to grid communication interface – Part 2 Technical protocol description and Open Systems Interconnections (OSI) layer requirements*

ISO/IEC 15118-3:2015, *Road vehicles – Vehicle to grid communication interface - Part 3 Physical layer and Data Link layer requirements*

ISO DIS 17409:2013-09, *Electrically propelled road vehicles – Connection to an external electric power supply – Safety requirements*

IEC 61851-1:2010, *Electric vehicle conduction system - Part 1 General requirements*

IEC CDV 61851-21-1:2014*, *Electric vehicle conduction system - Part 21-1 – Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply*

IEC CDV 61851-21-2:2014*, *Electric vehicle conduction system - Part 21-2 – EMC requirements for OFF board electric vehicle charging systems*

IEC 61851-23:2014, *Electric vehicle conduction system - Part 23 – D.C. electric vehicle charging station*

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

IEC 62196-2:2011, *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 FDIS 62196-3:2014*, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 3 – Dimensional compatibility and interchangeability requirem. for d.c. and a.c./d.c. pin and tube-type contact vehicle connectors*

IEC CDV 62752:2013, *In-Cable Control and Protective Device for mode 2 charging of electric road vehicles (IC-CPD)*

IEC/TS 62763:2013-12, *Pilot function through a control pilot circuit using PWM modulation and a control pilot wire*

DIN SPEC 70121:2014-12, Electromobility - Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System

Appendix B Documents for the CCS Extended

The following documents are expected for the implementation of the CCS Extended. Please note that some International Standards are not finally issued having an IS-Status by ISO and IEC.

ISO/IEC 15118-1:2013 Ed1, *Road vehicles – Vehicle to grid communication interface - Part 1 – General information and use-case definition*

ISO/IEC 15118-2:2014 Ed 1.0, *Road vehicles – Vehicle to grid communication interface – Part 2 Technical protocol description and Open Systems Interconnections (OSI) layer requirements*

ISO/IEC 15118-3:2015 Ed 1.0, *Road vehicles – Vehicle to grid communication interface - Part 3 Physical layer and Data Link layer requirements (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

ISO 17409 Ed 1.0, *Electrically propelled road vehicles – Connection to an external electric power supply – Safety requirements (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC 61851-1 Ed 3.0, *Electric vehicle conduction system - Part 1 General requirements*

IEC 61851-21-1 Ed 1.0, *Electric vehicle conduction system - Part 21-1 – Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC 61851-21-2 Ed 1.0, *Electric vehicle conduction system - Part 21-2 – EMC requirements for OFF board electric vehicle charging systems (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC 61851-23:2014, *Electric vehicle conduction system - Part 23 – D.C. electric vehicle charging station*

IEC 62196-1 Ed 3.0, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 1 – General Requirements (at the time of publication of this document Ed 3.0 not published by IEC as International Standard)*

IEC 62196-2:2011-10, *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 62196-3 Ed 1.0, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 3 – Dimensional compatibility and interchangeability requirem. for d.c. and a.c./d.c. pin and tube-type contact vehicle connectors (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC 62752 Ed 1.0, *In-Cable Control and Protective Device for mode 2 charging of electric road vehicles (IC-CPD) (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC/TS 62763:2013, *Pilot function through a control pilot circuit using PWM modulation and a control pilot wire*

DIN SPEC 70121:2014-12, *Electromobility - Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System*

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Appendix C **Bibliography**

The following documents are only for information purposes and are dispensable for the application of the Implementation Baseline.

ISO/IEC CD 15118-4:2014, *Road vehicles – Vehicle to grid communication interface - Part 4 Network and application protocol conformance test*

ISO/IEC AWI 15118-5:2012-06, *Road vehicles – Vehicle to grid communication interface - Part 5 Physical layer and data link layer conformance test*