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Mode 2 Charging - Testing and Certification for an International Market Access

Author

Dieter Hanauer, VDE Pruef- und Zertifizierungsinstitut GmbH, Merianstrasse 28, D-63069 Offenbach, Germany, dieter.hanauer@vde.com

Summary

Vehicle manufacturers are used to follow "UNECE Vehicle Regulations" to receive worldwide market access for their vehicles. Up to now there are 138 regulations. For electric road vehicles ECE-R 94, ECE-R 95 and ECE-R 100 are important regulations in terms of protection against electric shock and other electric hazards. Equipment being connected to public power supply needs to fulfil a harmonized worldwide set of international standards, as well as national or sometimes even local requirements. Electric Vehicles do have an interface to public power supply to recharge the vehicle (traction) battery. ECE regulations name it more general "Rechargeable Energy Storage System" (RESS). Up to now a battery is the only rechargeable energy storage system used in electric vehicles commercially available. Therefore national or even regional regulations have to be considered for car makers also to get market access. Elder electric power supply installation in private homes may cause risks by not being up to date. Therefore Mode 1 charging is forbidden in some countries. To ensure a safe charging at unknown power supply installation the standard IEC 62752 was published in 2016 to protect users and other people. This "intelligent" charging cable reduces risks even being connected to old energy supply not fulfilling up to date installation regulations. This paper points out some requirements and testing of Mode 2 Charging Assemblies which are found to be challenging requirements as well as the advantage of International Certification Service to know all requirements as well as getting worldwide market access.

Keywords: EVSE, infrastructure, market development, regulation, safety, standardization

1 International Standardization and Regulation

1.1 Standardization Groups and Trading Zones

For historical reasons national standardization have been establish to achieve interoperability and to ensure a minimum safety standard to reduce risk while using corresponding products. Because of worldwide business activities harmonisation of standards has been started. This is an ongoing process. For electrotechnical issues the **IEC** "**I**nternational **E**lectrotechnical **C**ommission" is the leading organization for international standardization. As can be seen from Figure 1 there are only a few countries not being member of the IEC.

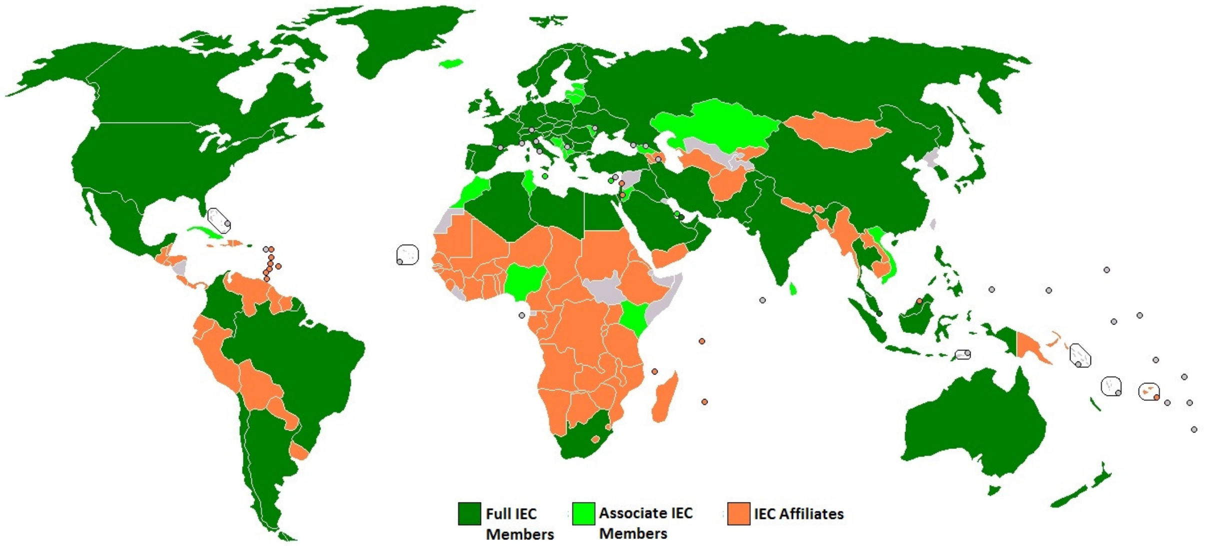

Figure 1 IEC Membership (2012) [1]

Because eMobility market is a relatively new market there is a lot of standardization going on. Figure 2 gives a rough overview of different working groups within IEC and ISO.

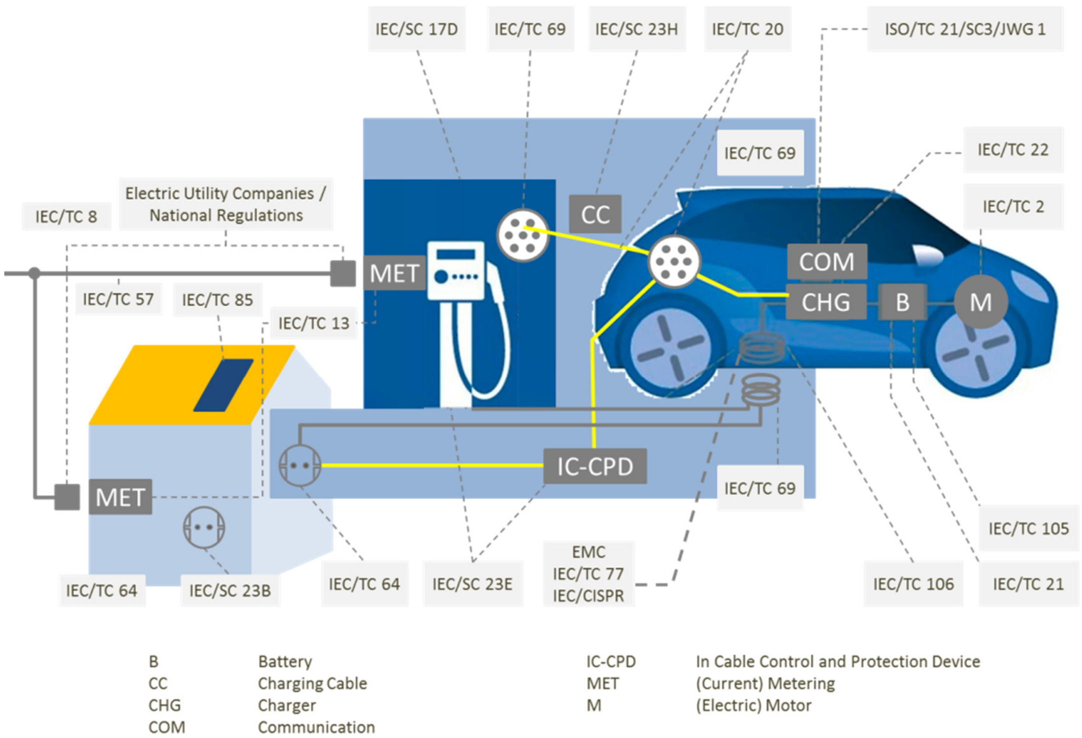

Figure 2: Different working groups within IEC and ISO to establish or adopt existing standards for eMobility to ensure interoperability and safe use of the different products

These international standards have to be transferred to national standards and regulations. Table 1 gives a rough overview about international standardization and its relationship to regulation.

Table 1 Example for international standardization and the relationship to regulations

	Standardization			Regulation
	General	Electro-technics Electronics	Telecommunication	
International Standardization	ISO	IEC	ITU	
European Standardization	cen	CENELEC	ETSI	
National Standardization (example Germany)	DIN	DKE VDE DIN	DKE VDE DIN	National Regulation

International standards will normally be transferred to the different trading zones. Within the trading zones these (adopted) standards are transferred to national (adopted) standards. The legislative authorities normally use the corresponding standards as a basis for regulations. So even having a “worldwide” standard because of technical or political reasons there are still national or local specialties. Therefore to achieve international market access is a lot of work.

Figure 3 gives a rough overview of the complexity of the worldwide market access.

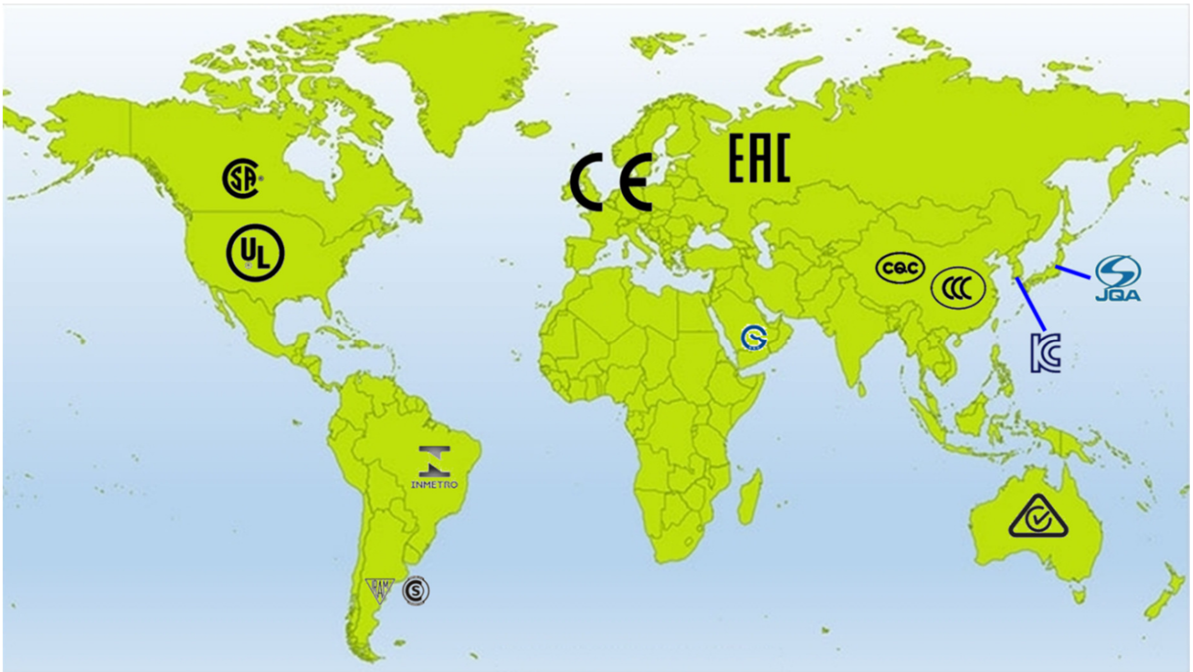

Figure 3 Rough overview of different certification for market access

Some countries require separate testing at local laboratories, some do accept tests done for instance according to CB-procedure of IECEE. The VDE Certification and Testing Institute is able to test and do the required certification for our customers to achieve access to the local market.

1.2 Current activities in standardization

The eMobility market has many improvements in products. New technical improvements have to be considered to ensure interoperability and safe operation. Therefore already existing standards go into maintenance status more or less when almost published.

Examples for ongoing and "new" standardization give an overview of existing market and future trends within eMobility (see also Figure 2):

- Improving IEC 62752 standard to implement actual development
- IEC 61851-1 has become a system standard for charging Electric and Hybrid Electric Vehicles
- EMC requirements for charging Electric and Hybrid Electric vehicles (IEC 61851-21-1/-2) are going to get finalized
- Standardization for pluggable/portable EVSE has started
- IEC 61851-23/-24 [DC-charging (200A, 500V)] is in maintenance status
- Standardization for High Power DC-Charging (450A, 1000V) has been started.
- Standardization for wireless charging is going on
- Standardization for Bi-directional charging (load levelling) has been started
- Standardization for e-Bikes, e-Scooter and even Trucks and Busses has started.
- etc.

Even eMobility is now starting to become a real mass market one has to ensure interoperability, reliability and safety. Because it is a new market the public is very sensitive to injuries.

Sometimes standards for certain products are not available or finished. Therefore a partner being familiar with electric safety, risk assessments, functional safety, interoperability etc. can be very helpful during design and validation. Furthermore it is mandatory to do a risk assessment and implement the results in the design and validation. Because of its fundamental knowledge about the application VDE is able to help the manufacturer.

2 Mode 2 charging equipment

2.1 Technical issues why to use Mode 2 charging

Before starting a description of Mode2 charging a short overview about the actual worldwide situation shall be given.

There are different types of connection systems for Electric and Hybrid Vehicles (AC and DC).

- Type 1 connection is based on SAE J1772
- Type 2 connection will be the standard AC connection within Europe
- Type 3 connection is a special AC connecting system using shutters
- AA describes connection according to CHAdeMO specification
- BB connection is used in China
- EE connection is a combination of DC and Type 1 (SAE J1772) connection
- FF connection is a combination of DC and Type 2 connection

Within Table 2 a description of different charging modes and its major electrical parameters is given.

Table 2 Description of different charging modes and its major parameters [3], [4], [5]

Charging Mode	Description	Maximum Current and Voltage
Mode 1	conductive connection between a standard socket-outlet of an AC supply network and electric vehicle without communication or additional safety features	16 A and 250 V AC, 1-phase 16 A and 480 V AC, 3-phase
Mode 2	conductive connection between a standard socket-outlet of an AC supply network and electric vehicle with communication and additional safety features	32 A and 250 V AC, 1-phase 32 A and 480 V AC, 3-phase
Mode 3	conductive connection of an EV to an AC EV supply equipment permanently connected to an AC supply network with communication and additional safety features	1: 32A and 250 V AC, 1-phase 2: 70 A and 250 V AC, 1-phase 63 A and 480 V AC, 3-phase 3: 16/32 A and 250 A AC, 1-phase 63 A and 480 V AC, 3-phase
Mode 4	conductive connection of an EV to an AC or DC supply network utilizing a DC EV supply equipment, with a (high level) communication and additional safety features	AA: 200 A and 600 V DC BB: 250 A and 600V DC EE: 200 A and 600 V DC FF: 200 A and 1000 V DC

Electric power supply in normal household is not always according to actual standards or regulations because of preservation of the status quo. The electric vehicle has a large touchable surface and may be connected to electric power supply for a long time outside in accessible area. Therefore specialists all over the world decided to establish a so called Mode 2 charging to reduce risk of electric shock.

Although it is normally forbidden, there are installations being enlarged by laymen. Different failures have been found even in well developed countries like Germany.

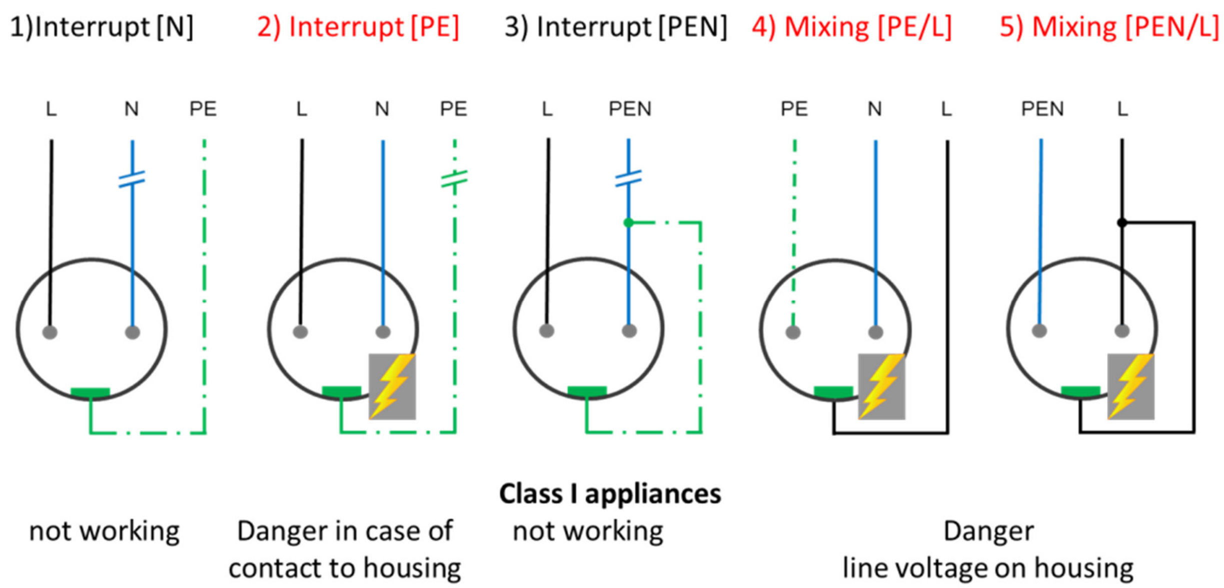

Figure 4: Possible failures within (private) power supply and possible risk using class I appliances (like electric vehicles).

As can be seen from Figure 4 different failures in electric power supply can result in different risks. Because of these foreseeable risks some countries don't allow Mode 1 charging. The described and other possible failures are the reason why Mode 2 charging for conductive low power charging has been established. Furthermore some countries limit the charging current in household. Even for 16A electric power supply 10A or 8A are allowed only to reduce the hazard of fire in electric power supply in elder houses. Therefore despite the established standards these limitations have to be considered. This can be done by implementing the correct duty factor of the Control Pilot Signal.

2.2 Contactor requirements

IC-CPDs will most likely be used daily. To achieve a reasonable service life, the contactors need to have a good mechanical as well as electrical endurance. For the design of the function box it has to be considered that the endurance of a contactor may depend on its orientation.

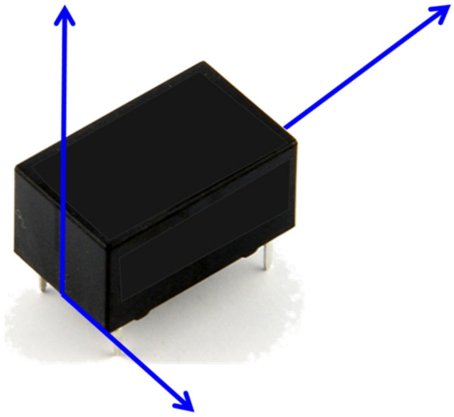

Figure 5 orientations of contactors

Furthermore, the endurance test of the IC-CPD is much different to standard test procedure of contactors or relays (See Figure 6).

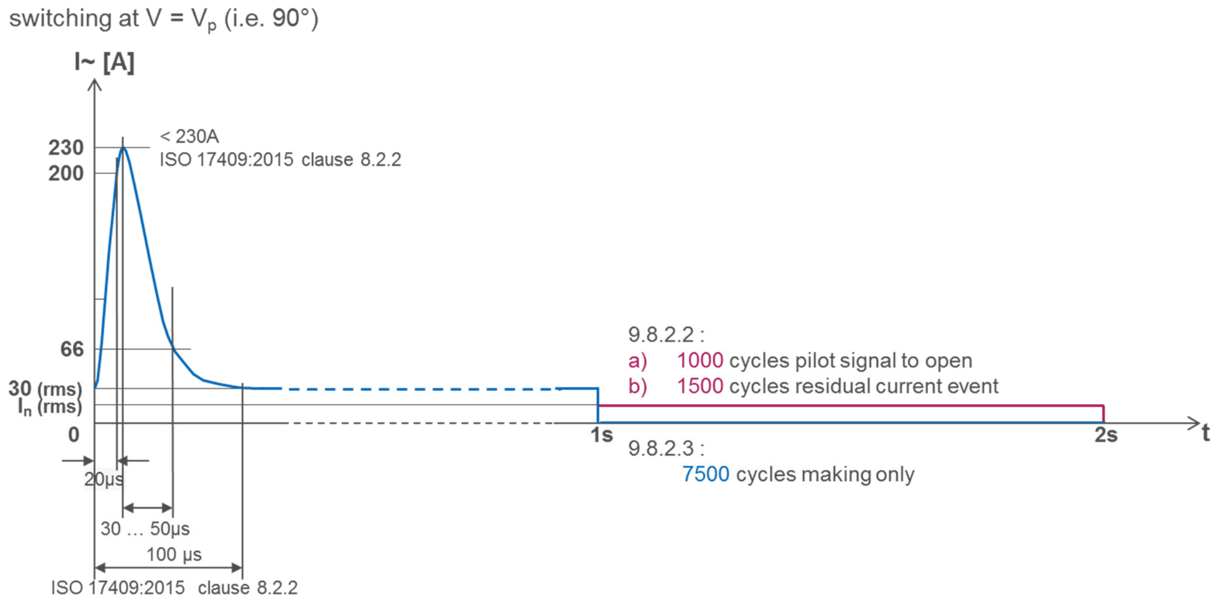

Figure 6: Endurance test pulses for IC-CPD

The influence on the calendric lifetime for different use of the IC-CPD is shown in Figure 7.

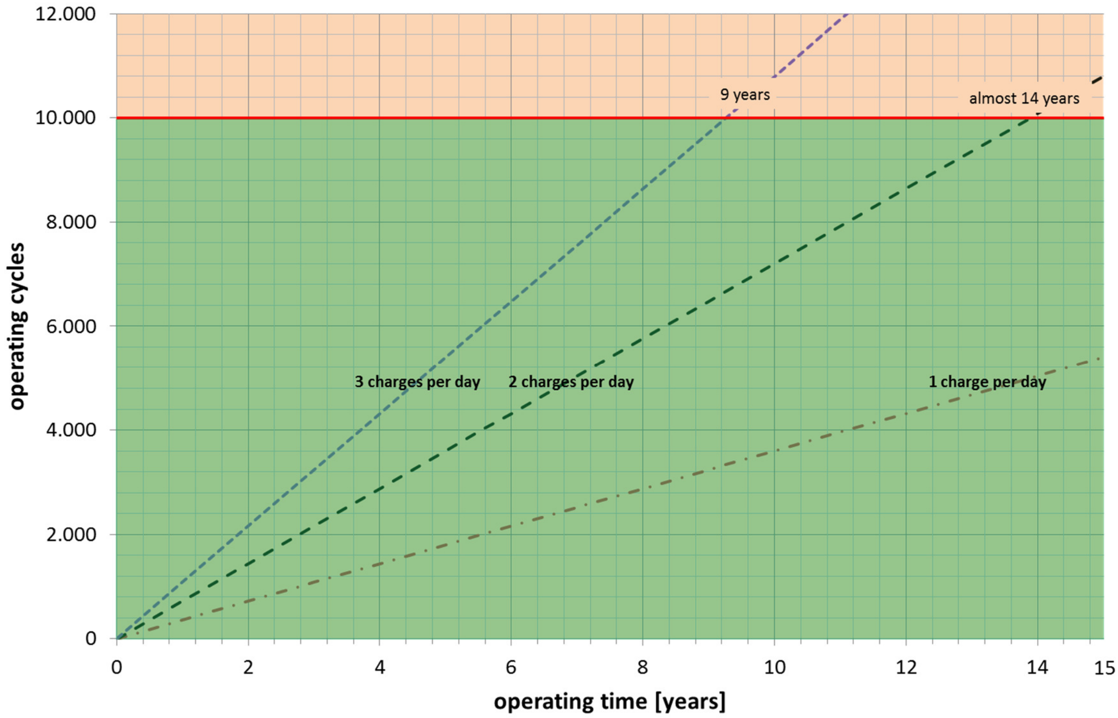

Figure 7 calendric life for a different use cases

2.3 dc residual current protection

During operation of high frequency chargers it is possible dc residual currents (pulsed or smoothly) will occur. If this will happen it is possible to “blind” the RCD Type C in the electric power supply of the house. Therefore it is recommended to use RCD Type B for Mode 3 and Mode 4 charging. For Mode 1 it is forbidden to use a charger producing a dc residual current of more than 6mA. For Mode 2 there has to be a protection for this. I.e. switch off power if a dc residual current exceeds 6 mA! Until Dec. 31st, 2017 it is allowed to sell IC-CPDs without this feature. But from Jan 1st, 2018 it is mandatory. This period has been implemented to get a chance to develop such protection device. Otherwise ISO 17409 would have to implement the requirement that dc residual currents (pulsed or smoothly) are prohibited.

2.4 National requirements

Besides the technical requirements stated within IEC 62752 (some are pointed out within previous clauses) there are sometimes additional national requirements for IC-CPDs. There are countries which require e.g. a suspension system to prevent excessive forces by the function box to the wall socket outlet. In some countries the cable length between plug and function box is limited to 30cm.

The following countries have national requirements not based on IEC standards:

- USA
- Canada
- Mexico
- Japan and
- China

These national requirements have to be fulfilled to get market access. These information's and some more are part of our international certification service. So the customer gets the testing and certification activities for the worldwide market access from VDE.

References

[1] WIKIMEDIA COMMONS, https://commons.wikimedia.org/wiki/File:IEC_membership.png, 2013-01-05 assessed on 2016-11-28.

[2] IEC 62752:2016-03 "In-cable control and protection device for mode 2 charging of electric road vehicles (IC-CPD)"

[3] IEC 61851-1:2017-02 "Electric vehicle conductive charging system – Part 1: General requirements"

[4] IEC 62196-1:2014-6 "Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 1: General requirements"

[5] IEC 62196-2:2016-02 "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"

Author

Dieter Hanauer

Dieter Hanauer is physicist and works as project manager for strategic projects at VDE Testing and Certification Institute. His main area of responsibility is eMobility business. He is working as development engineer and project manager in electric and hybrid vehicle business since early 1990th.