The Insulation is what counts

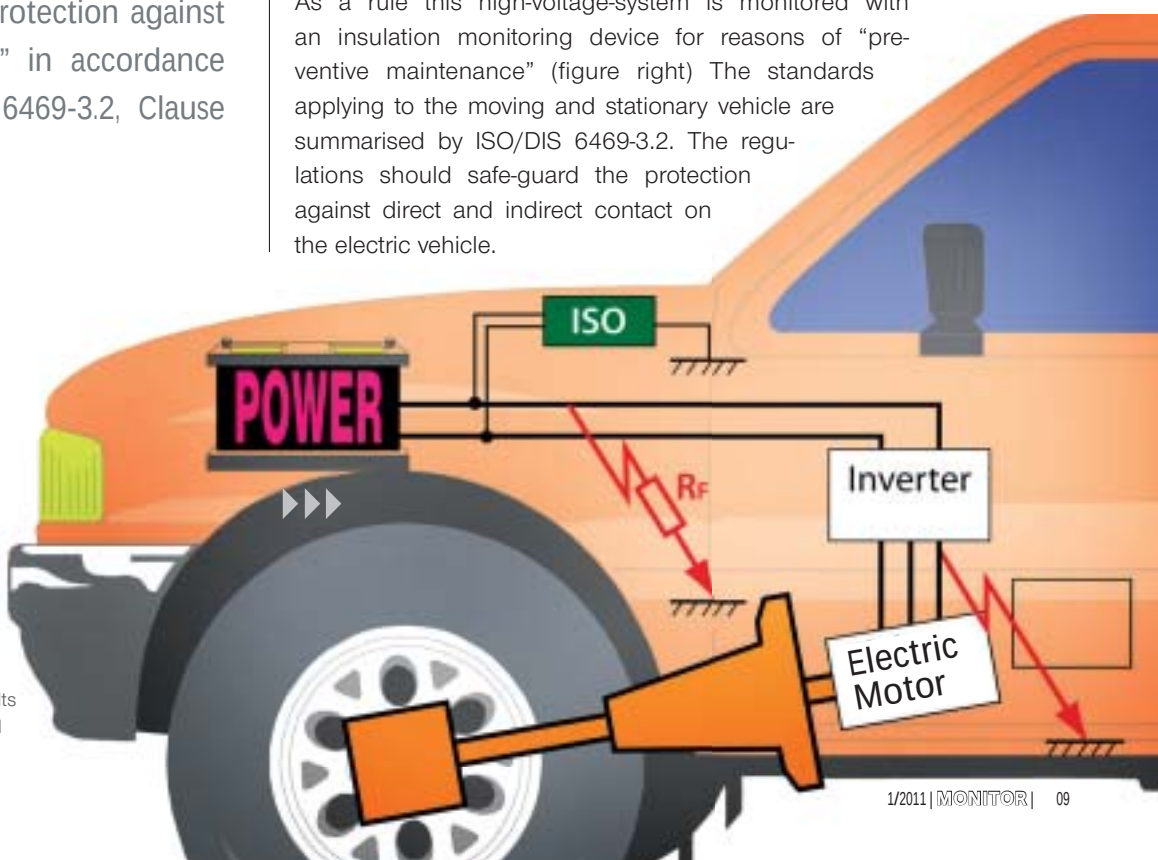
Standardisation has a key role to play in e-mobility and also in electrical safety. It is therefore imperative to take a closer look into this subject related, various ISO (International Standards Organisation), IEC (International Electrotechnical Commission) and DIN VDE standards and regulations, see frame 1. In particular, attention must be paid to the "protection against electric shock" in accordance with ISO/DIS 6469-3.2, Clause 7.1 (frame 2).

Similar to general electrical installations

fundamental protection scenarios can also be translated to the electric vehicle. Protection against electric shock ...

- ... in the moving vehicle
- ... in the stationary e-vehicle
- ... on charging the e-vehicle
- ... on working on the e-vehicle (e. g. maintenance)
- ... in the event of an accident with an e-vehicle.

The majority of automotive manufacturers install an insulated DC system in the e-vehicle, called the high-voltage-system (HV), which supplies the high-voltage consumers. As a rule this high-voltage-system is monitored with an insulation monitoring device for reasons of "preventive maintenance" (figure right) The standards applying to the moving and stationary vehicle are summarised by ISO/DIS 6469-3.2. The regulations should safe-guard the protection against direct and indirect contact on the electric vehicle.



An insulation monitoring device detects insulation faults in hybrid vehicles and e-vehicles

Standards situation according to ISO/DIS 6469-3.2: 2010-06	Electrically propelled road vehicles – Safety specification – Part 3: Protection of persons against electric shock
Protection of persons against electric shock, Clause 7.1 General Clause 7 Measures and requirements for the protection of persons against electric shock 7.1 General Protective measures against electric shock shall comprise of: • basic protection • measures for protection under single fault conditions.	**Measures for protection on the occurrence of a first fault, Clause 7.3** The protection under first fault conditions states that the following protective measures should be applied: • periodic or continuous monitoring of the insulation resistance • double or reinforced insulation • layer of barriers/enclosures in addition to the basic protection.

For charging the e-vehicle reference is made to other current international standards. It is noteworthy that here ISO/DIS 6469-3.2 is stated for the protective measures on-board the e-vehicle and IEC 60364-4-41 for the protective measures outside the e-vehicle. The reason: The protective measures must reconcile the existing types of system and the protective devices of the supplying system and of the supplying HV-system.

An example of a charger (type of system) is shown on page 11; others are conceivable. The at first glance unusual consequence of this analysis: For safely charging an e-vehicle, the type of system based on the type of earth connection of the supplying system must be considered. In other words: the type of system based on the type of earth connection forms the basis for the analysis of protective measures in relation to the high-voltage-system in the e-vehicle!

The relevant types of system are TT, TN and IT systems. The conductive parts (housing or chassis) of the equipment in an IT system are connected as in a TN system.

The system to be supplied (isolated high-voltage-system) in the e-vehicle can be comparable to an IT system. Crucial for this analysis of protection is the physical arrangement and design of the “charger” (see diagram on page 12).

If the charger is installed in the e-vehicle with simple separation (“on-board-charger”), two systems which are separated from each other and with different system types must be taken into account for the fault evaluation in regards to the protection against electric shock. In this case protection against electric shock is to be ensured using a residual current protective device (RCD) of type A.

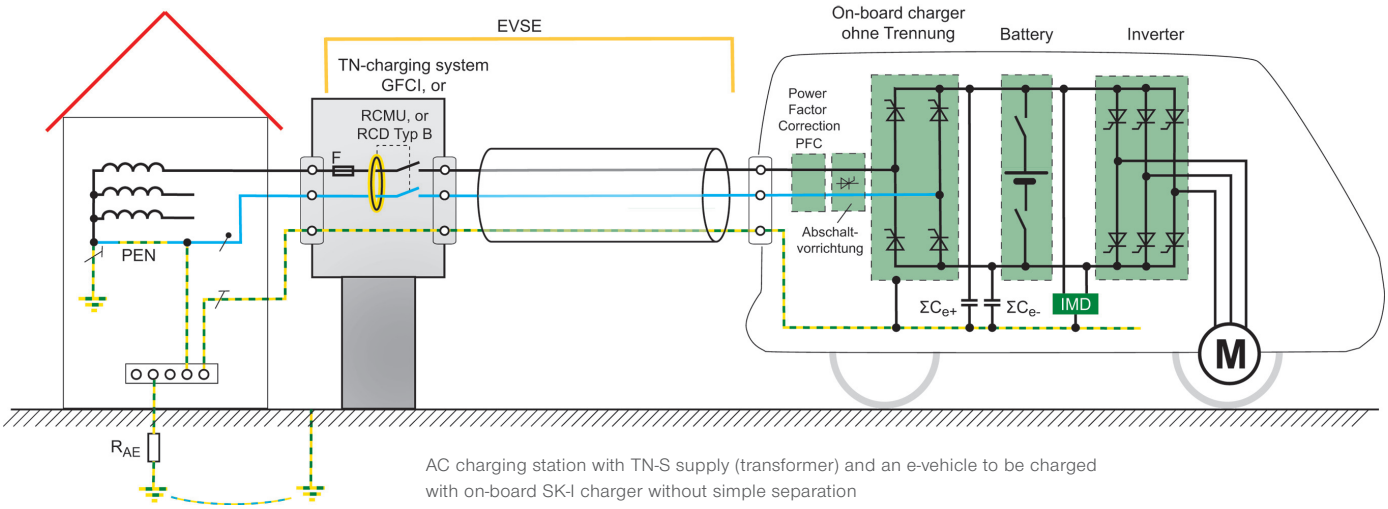
If the charger in the e-vehicle is without simple separation, a joint system with AC and DC components has to be considered for the fault evaluation. In this case, protection against electric shock is possible with a residual current

Insulation monitoring device for an e-vehicle

protective device (RCD) of type B. Here other devices are also conceivable, e.g. residual current monitoring units (RCMU), similar to those used for photovoltaic installations, in accordance with DIN V VDE 0126-1-1 (VDE V 0126-1-1):2006-02.

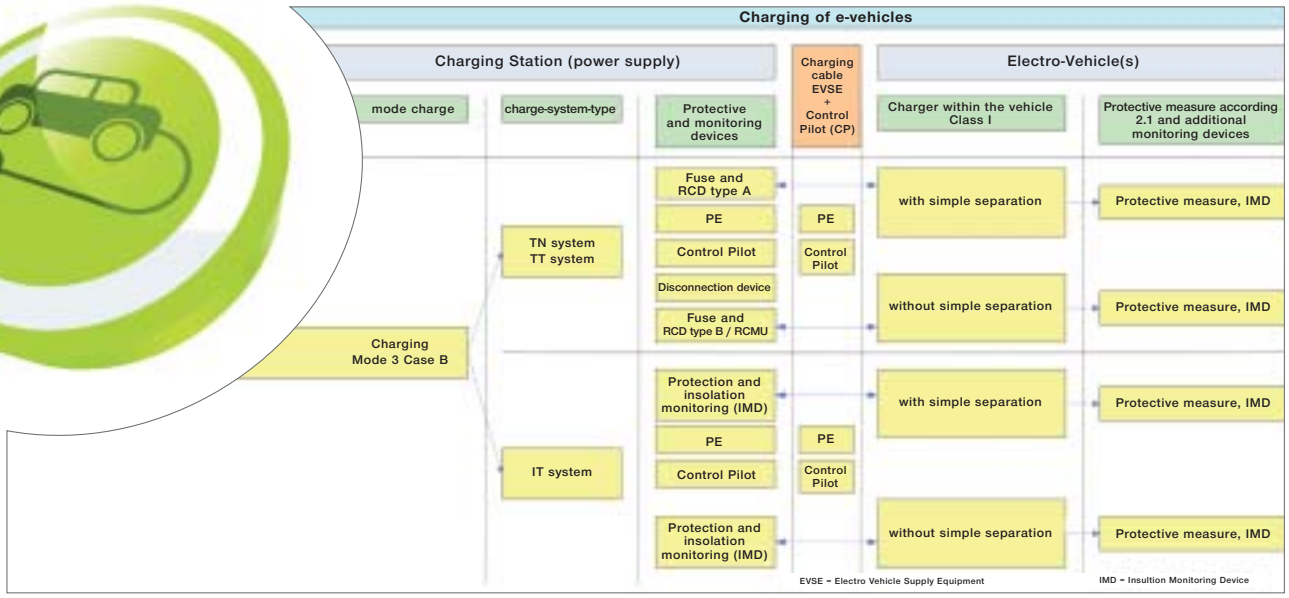
The design of the supply to the charging device as an IT system with insulation monitoring offers advantages in relation to protecting people touching the e-vehicle from outside the e-vehicle against touch voltages. The standard IEC 61851-1/FDIS also refers to this aspect: “Where power supply circuits that are galvanically separated from mains and are galvanically isolated from earth, electrical isolation between the isolated circuits and earth, and between the isolated circuits and exposed conductive parts of vehicle and EVSE shall be monitored. When a fault condition related to the electrical isolation is detected, the power supply circuits shall be automatically de-energized or disconnected by the EVSE.”

On the technical and normative sides of the project “Electro-mobility”, a project with considerable future potential, significant efforts have been made to provide protection against electric shock. The electrical equipment of e-vehicles



AC charging station with TN-S supply (transformer) and an e-vehicle to be charged with on-board SK-I charger without simple separation

Charging e-vehicles using charging cable EVSE with control pilot for TN, TT and IT charging system.



and of charging stations of the future depends on many factors. Reference has been made to the significance of the types of system, the protective devices and monitoring devices. Here the possible coupling of AC and DC systems during charging is of particular significance. The type of protective devices and/or monitoring devices applied, will be decided by the design of the future charger as an on-board or off-board version. The question of the functional safety of equipment in e-charging stations must also be finally clarified.

Safety while working on the e-vehicle (for example during maintenance) involves checking the state of the insulation of the high-voltage-system installed in the e-vehicle before work begins. Sufficiently high insulation

Standards situation regarding the electrical safety of equipment for charging

DIN VDE 0100-410 (VDE 0100-410): 2007-06,
Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock

DIN EN 61140 (VDE 0140-1): 2007-03,
Protection against electric shock – Common aspects for installation and equipment; Definition 3.23: simple separation – separation between circuits or between a circuit and earth by means of basic insulation

DIN V VDE 0126-1-1 (VDE 0126-1-1): 2006-2,
Automatic switching device between a generator parallel to the system and the public low-voltage grid (original title translated)

New Project: DIN VDE 0100-722 (VDE 0100-722)
(Responsibility: DKE, AK 221.1.11)
Errichten von Niederspannungsanlagen – Teil 7-722: Anforderungen für Betriebsstätten, Räume und Anlagen besonderer Art – Speisung von E- Fahrzeugen

International:
(Responsibility: IEC, TC64)
Project: IEC PNW 64-1714 Ed. 1.0, IEC 60364- 7-722: Low voltage electrical installations: Requirements for special installations or locations – Supply of electric vehicles

IEC 61851-1, ed2.0: 2010-11,
Electric vehicle conductive charging system – Part 1: General requirements.

values will ensure protection on indirect contact (protection under fault conditions). In case of a fault, equipment for insulation fault location can be useful. The electrically skilled persons in the vehicle workshops must be particularly well trained and familiarized with the potentials hazards.

Safety in case of an accident with an e-vehicle: The prerequisites stated for working on the e-vehicle apply here as well. Because of possible direct contact with the high-voltage-system particular care is required. ■

Dipl.-Ing. Wolfgang Hofheinz, CTO

CONCLUSION

Particularly during the analysis of the protective measures, the attention should be focused on where the supplying AC systems meet with the DC systems in the e-vehicle. These (problem) situations are familiar in the photovoltaic sector for years. Not all possible solutions have yet been discussed. While considering charging station safety, a possible alternative to universal AC/DC current-sensitive residual current protective devices (RCD) of type B could be the application of residual current monitoring units (RCMU) according to DIN V VDE 0126-1-1 (VDE V 0126-1-1), which have proven themselves over a number of years in the photovoltaic sector. In the field of electro-mobility further considerations and risk assessments are required in relation to protection against electric shock. If the current on-board charger in the e-vehicle is exchanged with an off-board charger, the protective measures for charging have to be revaluated.