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Tested: charging stations for electric vehicles

Standards ensure clarity and high standards of quality. Flexible measuring instruments and connection adapters are required.

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With the electric vehicle (EV) market becoming more significant in Europe over the past years, also the need for charging points is steadily increasing. Infrastructure and demand for EV's have a "chicken and egg" like relationship as the more vehicles that are on the road, the more demand there is for charging stations, but the amount of charging stations deployed can also hinder the adoption of EV's. With the EV market becoming more relevant, also the number of charging points has been steadily increasing, and according to association and media reports, there should be about 220,000 chargers by 2020 in western and northern Europe.

Source: https://www.euractiv.com/wp-content/uploads/sites/2/2018/09/Charging-Infrastructure-Report_September-2018_FINAL.pdf

There are numerous effects of faulty charging stations, including overloads of the power supply system, equipment and system failures and danger for people.

"It is particularly evident from public charging stations how important initial testing and approvals as well as periodic testing are. After all, these are technical laymen who operate these systems,"

–Werner Käsmann, Technical Sales Manager at Fluke.

The relationship is quite simple: Each faulty charging station slows the demand for electric cars due to the unreliable supply infrastructure. If countries want to make progress on electromobility, there are no gaps in supply allowed. Many cities throughout Europe are already responding to this with their own expansion plans as part of a balancing act in view of the shortage of parking spaces in urban areas. Each new charging station must comply with the relevant European standards for electrical systems. The general regulations that must be applied include HD 60364-6, HD 60364-7-722, HD 60364-5-54 and HD 60364-4-41 as well as HD 60364-5-52.

In accordance with HD 60364-6, all qualified electricians are obligated to perform an initial test on a low-voltage system after commissioning. The tests include measuring, inspecting and testing the different operating states of a charging station. Standard measurement procedures include measuring the continuity of the protective earthing conductors (PE), the functionality of the RCDs and the insulation and earth resistance. During the initial and subsequent periodic tests, it is important to know which charging mode is being used.

Four methods of charging

A look into the current operating practice reveals four different wired charging modes based on system standard DIN EN 61851-1, referred to as charging modes 1, 2, 3 and 4.

EN 61851-1 describes charging **mode 1** as charging with a maximum of 16 A using single-phase socket outlets with earthing contact (in most European countries Schuko-socket) or three-phase industrial sockets (e.g. CEE socket). Mode 1 is typically used to charge small electric vehicles such as e-bikes, e-motorcycles or e-scooters. In this mode a RCD (residual current device) is stringently required.

Mode 2 describes single or three-phase AC charging with double current up to 32 A, also with household or industrial sockets. The main difference compared to mode 1 is that mode 2 uses a special charging cable with an integrated control and protective device. The IC-CPD (In-Cable Control and Protection Device) protects the user from an electrical shock caused by insulation defects if he has connected his vehicle to a power outlet that is not intended for charging.

Mode 3 covers permanently installed charging stations with a charging cable and specially designed vehicle connections of type 1 and 2. The system includes built-in safety functions, such as a residual current device (RCD). The Equipment is deployed in practice to provide a quick charge with a single or three-phase alternating current of up to 32 A for all commonly used electric vehicles.

In contrast to charging mode 3, mode 4 charges vehicle batteries with up to 400 A DC. For this purpose, the charger is integrated into the station. The other structural features are similar to mode 3: Permanently installed charging station with fixed charging cable, lockable plug-in connections (Combo 2 or CHAdeMO) as well as protective functions within the charging station.

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Standards: ensure clarity and high standards of Quality

In general, for electrical planning, connections with power ratings above 2 kW have their own circuit. In assessments of single-phase charging stations, the diversity factor is 1. It should also be noted that socket outlets with earthing contact for household purposes use can only be used for short periods with a maximum current of 16 A. If continuous power up to 3.7 kW is required, socket outlets with suitable protections are used (e.g. CEE 16/3). The design of the supply cable must also comply with HD 60364-5-52. "It is advisable to add additional evaluation of the durability of plug-in devices," explains Werner Käsmann. This also includes temperature evaluation after one hour of continuous operation. A maximum temperature increase of 45 Kelvin is tolerable. Possible fire loads can be easily identified using the latest technology. For these purposes Fluke has developed the new PTi120 thermal imaging camera. Its values can then be easily evaluated and assigned in conjunction with the new Fluke Connect asset tagging software.

Charging mode simulation

When testing charging stations, the results must accurately and repeatable represent the actual charging processes. Consequently, an electric vehicle must be simulated during testing at a charging station, as the charging station will not release a charging voltage without vehicle simulation. Fluke has developed the Beha Amprobe EV-520-D test adapter kit for this purpose. The kit simulates the vehicle as well as different charging cable cross sections for power outputs of up to 22 kW. Once the charging voltage is released, the tests can be carried out at the charging station outlet using the measuring adapter and the installation tester. In addition, the initial test includes a visual inspection and low-resistance measurement of the protective earth (PE) and equipotential bonding conductor up to the charging station and to the charging connection.

Measuring adapter: it makes the real difference

The test Adapter kit Beha Amprobe EV-520-D differs from other products on the market by his adaptability. With the adapter, test single-phase charging stations can be tested with a type 1 socket in the same way as charging stations that have type 2 sockets installed. The EV-520-D can also be used for stations with permanently connected charging lines and type 2 charging interfaces. Despite the large number of charging station manufacturers, the kit can still offer this level of flexibility because it allows varying test simulations and cable cross sections to be set. Both connections for the control pilot signal output (CP) are used during commissioning. The pilot signal (PWM) is checked to ensure that it is communicating correctly with the vehicle to be charged.

Overall, the Beha-Amprobe solution can test a huge variety of charging stations with just one test adapter. To ensure durability and operational reliability, especially in outdoor areas, the EV-520-D is equipped with 4-mm dust and water-protected measuring sockets. The PE pre-test function is one of the highlights of the kit. It enables an initial assessment of a possible presence of voltage on the protective earth conductor (PE), which makes it especially useful during operation.

In practice: test sequence during commissioning

Once the visual inspection and low-resistance measurement have been completed and the charging voltage is switched off, an active measurement can be carried out on the test adapter using the Beha Amprobe Pro-Install 200 installation tester.

The sequence of test steps to be followed is defined by the standard HD 60364-6. A test always starts with a visual inspection. The continuity of the protective earth conductors (PE) and their connections must be carried out by measuring the resistance with a test current of at least 200 mA. The specifications for evaluating the measurement results are evaluated in accordance with HD 60364-6, Annex A, Table A.1 based on the cable length and the cross section. The insulation measurement can only be carried out after this measurement. Depending on the design of the system, the fault loop impedance must be measured and evaluated in relation to the upstream protective device in order to be protected by automatic shutdown. Since the installation of charging stations involves a special type of system, the specification for the selection of an RCD given in HD 60364-7-722, which specifies the use of RCD type B when DC fault currents occur, should be observed. This must then be checked for compliance with the shut-down conditions using the relevant test procedure. If counting devices are installed, the rotating field must then also be checked. A load can also be connected to the test adapter and the power socket on the rear. This can then be used to check that the energy detection system is functioning correctly.

In practice: periodic verification

Clause 6.5 of HD 60364-6 must be followed for periodic verification. If the periodic tests include electrical safety as well as the operating states of the pilot signal in accordance with EN 61851-1, then the PWM signal must also be measured using an oscilloscope. The graphical signal display provides the user with important information about possible faults in the communication between the vehicle and the charging station. If an external interference occurs due to a fault in the mains, the Fluke 125B ScopeMeter will accurately display the interference. This means that the existing measurement system, charging adapters, installation testers and portable oscilloscopes are a valuable investment for quickly finding and fixing faults in the charging infrastructure.

Conclusion

Electric vehicles are here to stay, but installing and commissioning the necessary charging stations requires electricians to have a suitable level of expertise. This applies to both the private and public sectors. Public charging stations especially demonstrate how important initial tests and regular periodic tests are, as public sites are operated by laymen. In the future, it will become increasingly important to be able to determine a fault in charging circuits safely and quickly using flexible measuring technology.

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