



CATALOG OF REQUIREMENTS
FOR THE LAYOUT
OF CHARGING STATIONS
ONBOARD OF RO-RO-FERRIES
Work Package 5.4

ALBERO Project

WP 5.4 Catalog of requirements for the design of charging stations to ensure safe onboard operation

Lloyds Register, Institute for Safety Technology/Ship Safety i.a.

The environmental conditions on board of vessels are different from those ashore. Accordingly charging stations to be installed on board should meet special requirements.

Demand and Supply

The selection of a suitable charging station should be done according to the following aspects, among others:

- **Number of electric cars** to be transported, customer demands: How many customers are asking for charging? What capacity utilization can be expected? Which number of charging stations seems to make sense? This can vary depending on the navigated area. In general, however, a significant increase in the number of electric cars can be expected in the coming years.
- **Time of passage:** If the passage takes less than 2 hours, fast charging stations are recommended, otherwise no satisfactory charging results can be achieved. If the passage takes more than 2 hours, fast charging stations are recommended too, but several vehicles have to be charged one after another at one charging station during the crossing. However, these consume more power than the ship may not have available in sufficient quantity.
- **Available power:** The number and capacity of the charging station(s) must be calculated according to the "surplus" power available on board. The safety of ship's operation takes priority in any case and must always be primarily guaranteed.
- **Maximum possible length of the charging cable:** Depending on the power the maximum possible length of the charging cable is limited. A longer charging cable allows greater flexibility in terms of positioning the vehicles and also allows to charge several vehicles in the vicinity of the charging station. On the other hand a longer cable may increase the risk of tripping and falling over or the damage of the cable when driving over it. If necessary, the cable routing e.g. from top down to the car should be reconsidered.
- **Type of charging plug:** There are several types of charging plugs available for electric cars. In any case, the charging station should offer the type 2 plug, which has been defined as the European standard. Some charging stations also offer (two) cable outlets with different plug types.

Technical Requirements

- **Electrical protection class:** Charging stations ashore offer an IP 54 protection class in accordance to the industry standard. For onboard operation a protection class of IP 55 (closed decks) or IP 56 (weather decks) is required for electrical installations to provide adequate protection against spray water. In addition, resistance to salty atmosphere should be provided proven by a separate standardized test.
- **Explosion protection:** Below the bulkhead deck electrical equipment must be approved to be used in ex-protection area zone 1, above the bulkhead deck in ex-protection area zone 2 but at least IP 55 at all decks. Charging stations ashore are not designed to be ex-protected as they are not foreseen to be installed in hazardous areas. On board this is only possible to a limited extent. Many decks or deck areas are designated as explosion protected zones up to a height of 45 cm or

fully protected (if dangerous goods are to be transported or below the bulkhead deck). All electrical installations in these areas must have an appropriate explosion protection. Since the implementation of this requirement is very cost-intensive an alternative location on board should be defined that is not subject to these requirements. It should be noted that the charging cable can also pose an explosion hazard, hence the installation of the charging station at a height of more than 45 cm would only make sense if the charging cable could also be installed at a corresponding height.

- **Vibrations:** Charging stations ashore are permanently installed, there are currently no requirements for vibration tests. Onboard charging stations should have at least the same vibration resistance as required for all other electrical installations on board. Electrical machinery and equipment used on board ships must be designed to withstand a vibration load of at least 0.7 g according to most classification regulations. This is based on vibrations in a defined frequency range (e.g. from 2 - 100 Hz according to the classification regulations of Lloyds Register).
- **Inclined positions:** No unintentional switching operations or functional changes may occur at electrical or electronic devices on board up to an angle of inclination of 22.5° to each side.
- **Electromagnetic compatibility:** EMC is the ability of an electrical device to function satisfactorily in its electromagnetic environment without unacceptably affecting this environment and other equipment. Conversely the electrical installation must not be disturbed by electrical devices within the environment. Corresponding regulations apply to electrical equipment that have to be complied on board. When charging electric cars the plug connection between the charging station and the car is a challenge. In this context the focus should also be placed on the rectifier (converter) of the charging station as this is clocked and works with power electronics.
- **Voltage and frequency deviations:** All electrical equipment on board must be designed to operate without interference coming from voltage and frequency deviations during normal operation. These deviations are defined for onboard equipment as follows:
voltage: +6/-10% (permanently) +20/-20% (temporarily)
frequency: +5/-5% (permanently) +10/-10% (temporarily)
The industrial standard ashore usually requires a tolerance of +10/-10% for voltage or frequency.
- **Network parameters:** While the transmission voltage ashore is usually at 400 V and 50 Hz most vessels are operating at 440 V and 60 Hz. A charging station must be able to function accordingly to these input values, this especially applies in particular if the conversion of voltage and frequency is done within the charging station and not by the car.
- **Power grid, grounding, distribution:** Charging stations ashore are designed for TT or TN networks which both guarantee grounding of the connected consumers via the distribution network. In both networks a zeroing of the electric circuit (neutral conductor) takes place. Within the TN network the neutral point of the source is directly earthed. The devices are connected to the neutral point of the network via a protective conductor. Within the TT network the neutral point of the network and the devices are separately connected directly to earth. Before the charging process can start the communication electronics between the charging station and the vehicle checks whether such earthing is present or not. If not, the charging process cannot begin. Onboard ships, however, an IT network is often used. Within the onboard IT network the neutral point of the network is not connected to earth. The devices are individually and separately connected directly to earth instead. For safety reasons and to ensure that the charging electronics detects a protective conductor an earthed network must be created by using an

isolating transformer. The transformer must be adapted to the performance parameters of the charging station.

- **Cable:** The cable should be firmly connected to the charging station in a way that no driver can use his own cables. If the cable is getting tight (e.g. movement of vehicles in heavy weather) the connection should be disconnected (emergency disconnection).
- **Integration into the onboard Power Management System:** The charging station should be integrated into the ship's Power Management System. An integration into a group of "unimportant consumers" would be recommendable. In case of high power demands the charging station can be automatically disconnected from the grid until sufficient power is available again.
- **Manual switch-off in special situations:** It should be possible to disconnect the entire charging station easily from the grid to stop further use, e.g. by a manual switch-off (access only for crew). This may become necessary, for example, if dangerous goods are transported at nearby parking spaces or if heavy weather is expected. The switch-off device (to disconnect charging station from power supply) should always be located in a non-explosive area/room. This can also be realized by integration into the Power Management System, if necessary.

Safety Measures and Monitoring

- **Integrated protection features:** The charging station must include all safety measures that are also required ashore. Among other things the functionality of communication between the charging station and the battery management system of the vehicle is required, e.g.
 - short circuit protection
 - overcharging protection – shut down if an overcharging of the battery occurs
 - internal cooling of the charging station or the charging cable, if necessary (depending on power)
 - temperature monitoring of the charging station, the cable and the plug - switch-off in case of damage and overheating
 - shutdown at a hazard alert of vehicle's battery management systemAdditionally certain ship-specific protection functions seem to be useful, e.g:
 - shutdown at severe angles of inclination
 - shutdown at strong external forces
- **Integration into ship's Alarm and Monitoring System:** The charging station should give an alert in case of internal as well as external malfunctions. The alert should be transferred to the bridge or to a permanently manned control center (e.g. engine control room).
- **Remote emergency shutdown:** In case of an accident, e.g. a fire nearby, it should be possible to remotely switch off the charging station.
- **Alarm:** If necessary, it may be useful for the charging station to trigger a noticeable alert in case of dangerous situations (e.g. problem within the charging station, with the connection or with the car battery). This alert must be audible and visually perceptible.
- **Monitoring:** In the vicinity of the charging station various detection systems are useful for early detection of hazards, e.g.
 - camera surveillance
 - gas sensor technology (e.g. hydrogen)
 - thermography, thermal imaging camera

The choice and design of monitoring depends on the specific location of the charging station onboard (open or closed deck, solar radiation, air circulation, ...). If certain hazardous limits are exceeded an alert should be triggered (bridge, acoustic, optical).

- **Fire prevention:** Locations of charging stations should be equipped with suitable, possibly additional, fire detectors. Water connection possibilities nearby are useful to extinguish a burning electric car. Before starting to fight the fire the charging process should be stopped and the charging station should be disconnected from the power supply!