

RISK ENGINEERING GUIDELINE

BATTERY CHARGING

HDI Risk Consulting

Property

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Battery charging installations are areas with a fire hazard and must be rated and marked as such.



General.

In trading and industrial activities, electric powered vehicles such as fork lift trucks and pallet trucks (industrial trucks) or mechanical sweepers (cleaning equipment) are powered by accumulator batteries. To maintain the operational readiness of these vehicles, the accumulator batteries - referred to as batteries below - must be charged at regular intervals and maintained appropriately.

Although developments in recent years have seen more efficient and lightweight batteries available (e.g. lithium-ion), electric powered vehicles normally use lead acid batteries. The electrolyte used in these batteries is diluted sulphuric acid. During the charging and discharging processes, the battery electrodes produce hydrogen gas and other by-products. This creates a potential explosion hazard which increases if the ventilation is insufficient or poorly designed.



Hence, battery charging installations must be designated as an area with a potential fire and explosion hazard. This usually requires complying with national regulations such as ATEX.

Battery chargers may be installed at fixed locations or as on-board units (depending on the producer or the customer). Charging may therefore take place at central battery charging stations, single charging points, or at any power outlet when using on-board units.

This Risk Engineering Guideline applies to chargers for industrial trucks and cleaning equipment exclusively. Chargers and charging equipment for electric road vehicles are not covered.

Fig. 1: A charger in a shelf compartment. The striking fact is that there is no fire separation between the battery charger and surrounding combustibles including the wooden pallet it is sitting on.

1 Risk situation and examples.

1.1 Risk situation

Fires in battery charging installations are usually attributable to technical deficiencies in the electrical equipment and to failure to observe safety measures.

Examples include:

- combustible materials stored or dumped in the immediate surroundings;
- lack of servicing and maintenance leading to:
 - increased contact resistance and degradation of insulation on connectors and charge cables respectively;
 - soiling and debris build up within the machine causing overheating;
- insufficient ventilation;
- overload of the power outlet;
- missing or insufficient collision/impact protection.

1.2 Examples

Example 1

In a furniture high-bay warehouse (storage height approx. 9 m), battery chargers are integrated into the storage shelves located throughout the facility as per figure 1. There is no structural or fire (space) separation between the charger and the surrounding storage.

As the charger is set up directly next to combustible material (wood, plastics, cardboard), a technical defect in the charger is highly likely to ignite these combustibles.



Fig. 2: Electric and mechanical overload of multiple socket-outlet

Considering the combustibility of the packaging material alone, rapid fire spread is to be expected, creating a high probability of a total loss of the stored goods and the building.

Such a loss will have negative consequences for the supply chain, leading to substantially reduced sales, increased cost-of-working, as well as the replacement cost of the damaged goods, buildings and equipment.

Example 2

A solar panel manufacturer had several battery chargers amongst production operations. These chargers are connected to a simple multiple socket-outlet (figure 2).

The socket is hanging freely rather than being suitably supported or fixed to a secure location. This can lead to damage of the socket, and increased risk of malfunction.

Secondly, the power rating of the socket is likely to be less than that of the chargers it is supplying. Thus there is a severe fire hazard due to the potential overload and subsequent malfunction of the socket.

Considering the sensitivity of solar cells and the production equipment to smoke damage as well as fire and heat, a fire would result in both high property damage and significant business interruption, due to the cleaning and repair of production areas and equipment.

2 Terms.

- **Batteries (accumulator batteries)**
Batteries are electrochemical energy storage devices. Batteries for electric powered vehicles normally consist of several cells electrically connected in series.
- **Battery charging installations**
Battery charging installations comprise of battery charging rooms, battery charging stations or individual charging points and the chargers.
- **Battery charging room**
A battery charging room is a room where batteries are charged. The chargers are located outside of this room.
- **Battery charging station**
A battery charging station is a location where batteries are charged. The chargers are accommodated in the same location.
- **Individual charging point**
An individual charging point is a place set up for charging batteries by suitable arrangement and marking. The above can also be transferred to the operation of on-board units.



■ Chargers

Chargers are electrical devices for charging batteries. They usually include:

- power supply connection,
- power supply unit (transformer),
- charging unit (rectifier) and
- connecting cables to the battery (charging lines).

3 Protective measures.

In general, consideration and measures regarding

- ventilation,
- fire protection,
- battery transport (including safe battery change),
- requirements of chargers and batteries,
- monitoring of charging and ventilation and
- mechanical damage to batteries (electrolyte leaks).

Further measures may be required due to structural conditions, operating sequences or official requirements. As a basic rule, a risk and hazard analysis must be prepared in accordance with local requirements and best practice e.g. ATEX regulations and associated standards. Below are examples of what must be explicitly taken into account:

- areas or business premises with a potential fire hazard;
- areas with a potential explosion hazard and areas subject to an explosives hazard (see also EN 60079 ff.);
- humid and wet areas.

As a basic rule, battery charging should not be allowed in the above areas.

Proper installation and implementation of all necessary safety devices and measures, including their maintenance, is the responsibility of the operating company.



Fires in battery charging units are usually attributable to technical deficiencies of electric equipment and to failure to observe organisational and technical safety measures.

3.1 Structural fire protection

Batteries should only be charged in battery charging rooms or at battery charging stations exclusively. These rooms and locations must:

- be separated from adjacent areas by a fireproof wall (fire resistance of 90 minutes);
- be sufficiently ventilated (see also EN 50272-3).

If individual charging points cannot be avoided in production or storage areas, and a horizontal clearance of at least 2.50 m from combustible materials cannot be maintained, the charging points must be separated from adjoining areas by walls made of non-combustible and non-heat-conductive materials. The walls must be at least 1.50 m higher than the charger and the electrical vehicle. Sufficient stability and/or fastening of the walls must be ensured.

Mechanical barriers (collision protection) protecting the charging devices and their accessories are considered best practice.

3.2 Organisational fire protection

During planning and setting-up of battery charging installations, the following organisational aspects should be considered:

- Battery charging rooms and locations must always be kept free of fire loads which are not directly required for operation.
- Storage of combustible materials above or below chargers is not permitted.
- The clearance of individual charging points from combustible materials must be at least 2.50 m horizontally.
- The clearance between the battery and the charger must be 1 m minimum in order to prevent ignition of the escaping hydrogen due to hot components or charger defects.
- To prevent mechanical damage to the charger cables and the sockets, these items must be suitably fixed and supported by means other than the power cable itself.
- Unhindered access to battery charging units must be maintained at all times.



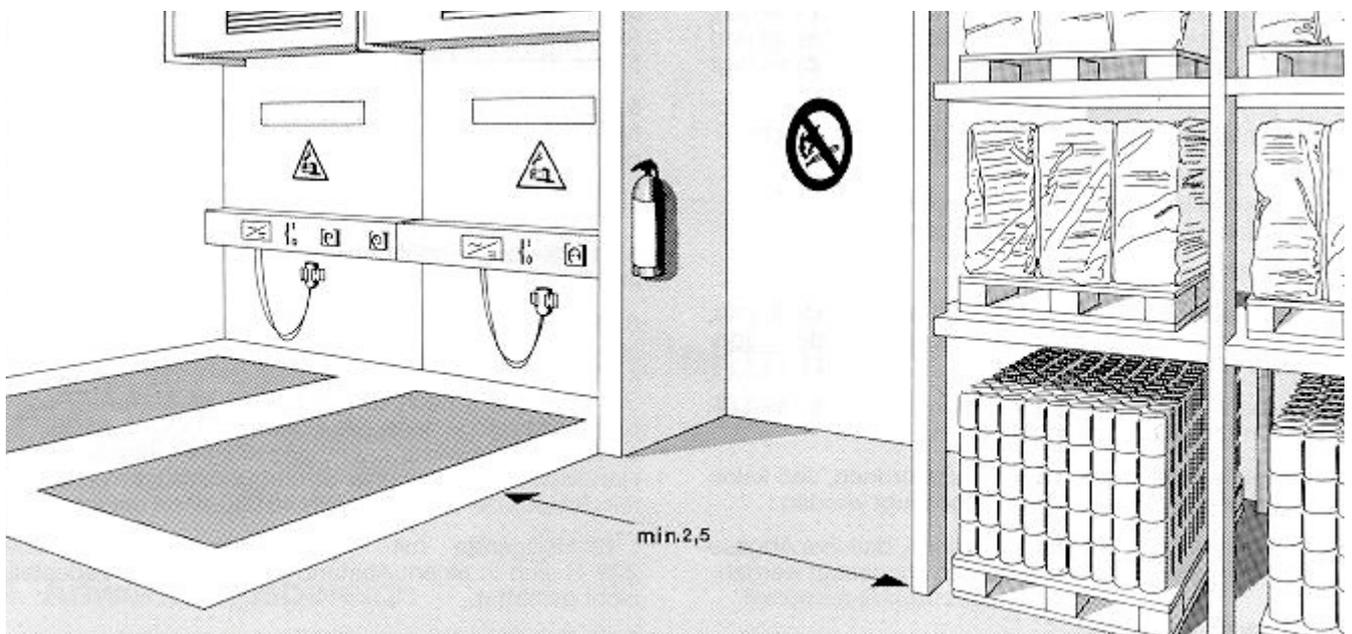
Fig. 3: Suitable setting-up of battery charging points.

- Safe and unhindered manoeuvring of industrial trucks must be ensured.
- Individual charging points must be clearly and permanently marked, e.g. using yellow hatching on the floor. Charging of electrical vehicles as well as single batteries should be restricted to these areas only.
- Battery charging stations and individual charging points must be set up in frost-free areas.
- Chargers and accessories must be suitable for the battery to be charged (observe the applicable manufacturer's specifications).
- Employees must be trained in the handling of batteries at regular intervals. Possible hazards resulting from failure to comply with the relevant safety regulations must be pointed out.
- Maintenance and repair work should only be carried out by qualified personnel.

As batteries are usually charged during unmanned periods, battery chargers should additionally be monitored by automatic fire detection system, preferably smoke aspiration systems.

3.3 Electrical system

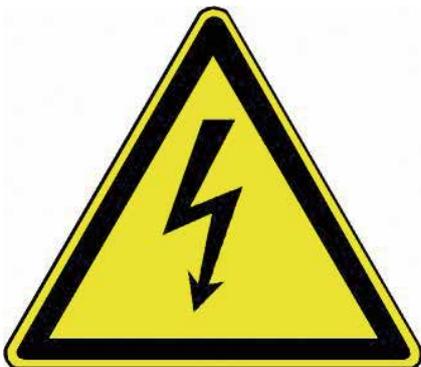
- Each battery charger must be individually protected against excess current and short-circuit on the power supply side. When using three-phase chargers, providing motor circuit-breakers with short-circuit release is useful.
- It must be possible to disconnect battery chargers from the supplying power supply network.
- Battery chargers must be protected by a residual-current circuit breaker (RCCB) with a rated fault current of ≤ 300 mA on the power supply side. RCCBs with a rated fault current of ≤ 30 mA are recommended.
- Battery chargers must be protected by excess current protective devices on the charge side. Rating typically follows the highest possible charge current.
- The cross-sections of the charge lines must be sized to suit the highest charge currents. The cross-section, however, should not be less 10 mm^2 for reasons of mechanical strength.
- The electric equipment must be maintained in accordance with the installer's standards including IEC 60364.6.



3.4 Marking according to ISO 7010 (Graphical symbols – Safety colours and safety signs – Registered safety signs)



Warning of hazards from battery charging (sign W026)



Warning of electric voltage (sign W012)



No open flames; Fire, open ignition sources and smoking are not permitted
(sign P003)

Additional signage may be necessary,
depending on local conditions.

3.5 Fire extinguishers

A sufficient number of CO₂ fire extinguishers must be made available at clearly designated and easily accessible points for fire fighting. Powder-type fire extinguishers, although effective for fire fighting in or on electric equipment, can cause considerable secondary losses and consequential damage due to the release of very fine and highly corrosive extinguishing powder. CO₂ extinguishers are preferred as they do not leave residues on sensitive electrical equipment.

To enable portable fire extinguishers to be used quickly and effectively when needed, employees must be trained in their proper use at regular intervals.

Reference is made to NFPA 10 Standard for Portable Fire Extinguishers.

4 Technical inspections.

4.1 Inspection

The battery chargers must be subject to an inspection at least once a year. This requirement is based on IEC 60364.6 and/or IEC 62638, the Operational Safety Decree and the maintenance instructions provided by the manufacturers amongst others. All inspections should be documented; it is good practice to use a decal to display the date of the last inspection. If any defect or damage is identified, the unit must be taken out of service and repaired or replaced.

Visual inspections of the equipment, especially the charging cables, must be carried out every working day. Particular attention must be paid to damaged insulation, kinks and cross-section reductions of the charging cables, and damage to electrical connections and the charger.

4.2 Thermographic inspections

Battery charging stations are to be included in the regular thermographic inspection of electrical installations.

The electrical connections between the individual accumulator batteries are important in this respect. The rectifier outputs and terminal connections inside the charger, however, can also be inspected by infrared thermography.



Chargers must be serviced and maintained at regular intervals to avoid damage.

5 References.

Local standards shall be complied with.

- NFPA 1 Fire Code, Chapter 52 – Stationary Storage Battery Systems
- NFPA 2 Hydrogen Technologies Code
- NFPA 10 Standard for Portable Fire Extinguishers
- NFPA 70 National Electrical Code
- NFPA 110 Battery chargers
- UL 1564 Standard for industrial battery chargers
- EN 1175 Safety of industrial trucks
- EN 50272-2 Safety requirements made on batteries and battery installations – part 2: Stationary battery
- EN 50272-3 Safety requirements made on batteries and battery installations – part 3: Traction batteries
- EN 60079 Explosive atmosphere
- IEC 62133 Standard for secondary cells and batteries containing alkaline or other non-acid electrolytes
- IEC 60364 ff Low voltage electrical installations
- IEC 62638 Recurrent test and test after repair and modification of electrical equipment
- ISO 7010 Graphical symbols – Safety colours and safety signs – Registered safety signs



About HDI Risk Consulting.

HDI Risk Consulting GmbH supports major corporations, industrial and mid-size companies with loss prevention and in establishing risk management systems.

HDI Risk Consulting offers its' customers access to some 180 engineers and experts from a wide range of technical disciplines. We aim to support companies with the management of risks and the development of individual risk-based concepts for insurance cover.

HDI Risk Consulting operates globally in the Property, Motor, Engineering and Marine markets, with particular focus on the identification and assessment of risks and the development of appropriate, individual protection concepts.

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Imprint:
In charge of the content:
HDI Risk Consulting GmbH

Layout: Insignio Kommunikation GmbH
Pictures: HDI Risk Consulting GmbH,
imagesoure, istockphoto, VdS

