**Ventilation of battery charging rooms for lead-acid traction batteries**

1. **Foreword**
   
   Battery charging rooms must be ventilated sufficiently to avoid risk of explosion. This ZVEI information leaflet aims to help in designing the ventilation of battery charging rooms for lead-acid batteries. It supplements DIN EN 62485-3 *Safety requirements for secondary batteries and battery installations – Part 3: Traction batteries*. It contains guidance and example calculations.

2. **General**
   
   Accumulators (i.e. batteries) that use aqueous electrolyte, including lead-acid ones, continuously decompose water due to their electrochemical properties. This leads to the formation of hydrogen and oxygen gases.

   This causes an explosive mixture to escape from the battery cells through the plug openings during charging, particularly near the end of the process.

   When the 'gassing voltage' is exceeded (e.g., 2.4 V per cell for lead-acid batteries), the water decomposes much more. In batteries with immobilised electrolytes, gas emission is typically reduced after several charging cycles, depending on the design.

   The longer the battery charges, the more of the charging current is promoting the gas formation. Once the battery is fully charged, the current still flowing only produces oxyhydrogen gas.

   Breaking down 1 gram of water into oxygen and hydrogen during charging requires 3 Ah. With an overcharging current of 1 A, electrolysis produces 0.45 litres of hydrogen and 0.23 litres of oxygen per cell per hour (at 25 °C).

   Ventilation for battery charging rooms should ensure the gas mixture created is diluted so the concentration of hydrogen stays below the lower explosion limit of 4 % by volume. These rooms should therefore be designed with enough natural ventilation (diagonal room ventilation, air inlets and outlets on opposite walls); alternatively, technical ventilation must be installed.

   Even with adequate ventilation, dilution of hydrogen is not always assured in the area immediately around a battery. DIN EN 62485-3 requires clearance of at least 0.5 m from a possible ignition source emanating from a cell opening (plug or valve). Open flames, sparks, arcs or glowing devices are not permitted within this safety distance (maximum surface temperature 300 °C).

3. **Ventilation dimensions**
   
   Enough air must be exchanged to dilute the potentially explosive gas mixture.

   The flow required is calculated per DIN EN 62485-3 for the reference temperature of 25° C, as follows:

   \[ Q = 0.055 \text{m}^3/\text{Ah} \times n \times I_{\text{gas}} \]

   where

   - \( Q \) is the air volume flow in m³/h
   - 0.055 m³/Ah combines the rate at which the gas develops, the necessary dilution factor for hydrogen and a general safety factor
   - \( n \) is the number of cells connected in series (e.g. 40 in an 80-volt or 12 in a 24-volt battery). Any cells connected in parallel are covered by the charging current, as this relates to the whole battery
   - \( I_{\text{gas}} \) is the hydrogen-generating electric current in A

   The safety factor means this formula can also be used for the entire permitted battery operating temperature range. 

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This leaflet was prepared by the Working Group Industrial Batteries of the ZVEI – German Electrical and Electronic Manufacturers’ Association, Batteries Division
The values of $I_{gas}$ for the relevant batteries should be enquired from the manufacturer of the chargers. The charger’s particular characteristics, e.g. pulse-, multi-voltage- or fast-charging functions, must be explicitly taken into account.

If no exact figures are available for the relevant charger, the value used for $I_{gas}$ should be at least 40 % of the maximum charging current (see charger’s type label).

If several batteries are charged simultaneously in the same room, the necessary air volume flow for each must be calculated. For safety reasons, assume that all batteries being charged produce hydrogen at the maximum gassing rate.

The required air volume flow for a charging station is therefore calculated by adding the flows for all batteries being charged in the same room, unless this can be ruled out by technical means.

**Example calculation of air volume flow:**

Mixed installation of PzS and PzV batteries.

Ten PzS batteries 80 V, 420 Ah, $C_5$, W0Wa charging characteristic with $I_{gas}$ (equates to charge cut-off current) of 21 A (example from charger manufacturer).

Calculation of air volume flow for one PzS battery:

$Q_{PzS} = 0.055 \text{m}^3/\text{Ah} \times 40 \times 21 \text{A}$

$= 46.2 \text{m}^3/\text{h}$

Calculation of air volume flow for the ten PzS batteries:

$Q_{PzS} = 10 \times 46.2 \text{m}^3/\text{h}$

$= 462.0 \text{m}^3/\text{h}$

Six PzV batteries 48 V, 300 Ah, $C_5$, IUla charging characteristic with $I_{gas}$ (corresponding to the end of charge current) of 3.6 A (example from charger manufacturer).

Calculation of air volume flow for one PzV battery:

$Q_{PzV} = 0.055 \text{m}^3/\text{Ah} \times 24 \times 3.6 \text{A}$

$= 4.8 \text{m}^3/\text{h}$

Calculation of air volume flow for the six PzV batteries:

$Q_{PzV} = 6 \times 4.8 \text{m}^3/\text{h}$

$= 28.8 \text{m}^3/\text{h}$

If all 16 batteries in the room have their own charging area, the required air volume flow is:

$Q_{total} = Q_{PzS} + Q_{PzV}$

$= 462.0 \text{m}^3/\text{h} + 28.8 \text{m}^3/\text{h}$

$= 490.8 \text{m}^3/\text{h}$

**4. Design of charging rooms**

Ventilation must be designed based on the calculated value of $Q$.

For the two variants

- natural ventilation
- technical ventilation

the following conditions apply:

**Natural ventilation**

The basic requirements for natural ventilation are a free room volume (total volume of room minus volume of objects in it) of $2.5 Q \times h \text{[m}^3]\), and a mean air velocity of 0.1 m/s (in room at rest).

Sufficient inflow and outflow of air must also be ensured.

The minimum cross-sectional area of air inlets and outlets is calculated as follows:

$$A = 28 \text{ cm}^2 \times \frac{h \text{[m}^3]}{Q}$$

where

- $A$ is the cross-sectional area of the air inlets and outlets in cm$^2$
- 28 cm$^2$ h / m$^3$ is the necessary factor for converting units
- $Q$ is the air volume flow in m$^3$/h

The necessary cross-sectional area can be provided by forming the sum of all the different openings in the building envelope.

The airflow must ensure that all parts of the battery charging station are ventilated: air should enter at ground level, be directed over the batteries and leave the room from as high up as possible (cross-ventilation).

If the air inlets and outlets are on the same wall, they must be at least 2 m apart.
Doors and windows can only be counted as inlets and outlets if they are continuously open during charging and provide the necessary cross-sectional area when in this open position.

**Example calculation of cross-sectional area of air inlets and outlets**

Using the example for an air volume flow from above, the required cross-sectional area for the air inlets and outlets is calculated as follows:

\[ A = 28 \text{ cm}^2 \frac{\text{h}}{\text{m}^3} \times Q_{\text{total}} \]

\[ = 28 \text{ cm}^2 \frac{\text{h}}{\text{m}^3} \times 490.8 \text{ m}^3/\text{h} \]

\[ = 13742 \text{ cm}^2 \]

For square openings, the resulting edge length is approximately 117 cm.

**Technical ventilation**

If the room does not fulfil the conditions for natural ventilation, a technical ventilation system must be installed to ensure the necessary air volume flow \( Q_{\text{total}} \).

Battery charging is allowed only when the technical ventilation is in operation.

The effectiveness of the technical ventilation must be verified when first putting the equipment into service and again at regular intervals.

**Other key requirements for natural and technical ventilation**

The inlet air must be free of gases that could damage batteries, e.g. chlorine and ammonia.

Ducts and components of the ventilation system exposed to the exhaust air must be acid resistant.

Natural and technical ventilation must be designed to release the exhaust air outdoors. Air outlets must be positioned away from air-conditioning system intakes. Exhaust air must not be fed into active chimneys.

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