ZVEI Batterien

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Opportunity charging of lead acid traction batteries

1. Introduction

This ZVEI information leaflet describes operating modes and operating parameters as well as important basic rules which have to be obeyed for the opportunity charging of lead acid batteries. It shall supplement the DIN EN 61044 and shall characterize the application possibilities and limitations of opportunity charging.

When opportunity charging, a partially discharged battery is charged in order to lift its state of charge between two complete charges. Thereby the full state of charge is not reached. Goal of opportunity charging (partial charges) is to prolong the daily operation time of the battery between two full charges, by using either operational breaks or recuperative braking respectively lowering for the partial charge of the battery. Fixed cycle operations which are especially applied for AGVs use a special form of opportunity charge. Here normally short discharge charge phases are followed by planned short charging phases.

2. Effects of opportunity charging

2.1. Discharge and energy turnover

The opportunity charge operation for the prolongation of the daily operating time is coupled with an additional energy turnover of the battery (>80% of the nominal capacity). This increased energy turnover effects the service life of the battery. The contemplations of the ZVEI leaflet “Considerations on the life of traction batteries“ have to be taken into account. Additionally the temperature of the battery will be significantly increased through the daily enhanced energy turnover (see chap. 4.3).

2.2. Charging and charge acceptance

The charge acceptance is the capability of the battery to store the charge that is offered to it. The amount of charge that can be stored is not a constant but a quantity which is dependent on different parameters:

- the depth of discharge of the battery
- the magnitude of the charge current
- the electrolyte temperature
- the duration of the charge

The lower the state of charge of the battery the better is its charge acceptance.

Each opportunity charge of a battery is a partial charge, in which lead sulfates as well in the positive plate as in the negative plate are removed. Charging losses through electrolysis are unavoidable.
The higher the charging currents are, the higher the losses through the heat evolution (RI^2) will become. Reaching the gassing voltage additional losses through gassing (electrolysis) and water loss will occur. The time for reaching the gassing voltage depends on the following parameter:

- the charging state of the battery (momentary state). The higher the charging state, the shorter is the time to reach the gassing voltage. This also implies a lower charging efficiency.

- the magnitude of the charging current. The higher the charging current the shorter is the time to reach the gassing voltage.

- the operating temperature of the battery.

This leaflet was prepared by the Working Group Industrial Batteries of the ZVEI – German Electrical and Electronic Manufacturer’s Association

Batteries with lower electrolyte temperatures have a higher gassing voltage and batteries with a higher electrolyte temperature have lower gassing voltages.

Nominal values:

2,4 Vpc for PzS
and
2,35 - 2,4 Vpc
(manufacturer specific)
for
GiS, PzV, GiV,
each at 30°C.

The charge acceptance decreases on reaching the gassing voltage. Reaching this voltage level a fraction of the charge will be going into side reactions. On charging above the gassing voltage with high charging current the side reaction will occur enhanced. An increased water consumption, higher gassing (hydrogen oxygen!), a strong temperature evolution and potentially sludging of the active masses result.

3. Operating modes of opportunity charging

For different operating modes of traction batteries different opportunity charge options arise, in order to safeguard a pro-longation of the operation time.

3.1. Opportunity charging in operational breaks

These can be during, e.g. operational brakes, truck loading breaks, etc. The operator of the equipment decides on the number and the timing of the opportunity charges.

These opportunity charges are conducted at the chargers which are provided for the complete charges. As these chargers are located in the charging stations or at the charging positions the building and ventilation related requirements are fulfilled anyway. The battery can reach and exceed the gassing voltage during the opportunity charging. The instruction manuals and especially the safety requirements for batteries and industrial trucks have to be respected.

3.1. Opportunity charging in cyclic operations

A cyclic operation consists of a sequence of partial discharge and charge cycles. The timing for opportunity charge is automatically given. The selection of the battery and the charging system, as well as the specification of the operating parameter and the limiting values, requires an application specific projection planning (see VDI 4451 page 2) and a consultation with the battery manufacturer. For this projection planning also the specialities concerning charging regime safety measures with respect to the ventilation requirements (DIN EN 50272-3) and the acid protection are considered.

3.2. Opportunity charging through energy recuperation

Regenerating braking or lowering achieves the recuperation of the kinetic respectively of the potential energy. This conversion is taking place with the assistance of the driving respectively lifting motors in the generator mode. In order not to endanger the safety of the industrial truck, the operator and the surroundings, the gassing voltage must not be exceeded when opportunity charging by energy recuperation.

Every opportunity charge through recuperation is a partial charge in battery terms. The charging times generally are very short and the recharged capacities very small.

4. Parameters for the opportunity charging of lead acid traction batteries

4.1. Charging regimes, limits of charging currents and voltages for the opportunity charging of lead acid batteries

As charging regimes preferentially regulated characteristics like IU-, IU0U-respectively IUIa-regimes should be used. For planned opportunity charges here the recharged capacity can be calculated better.

For the current limit values of the chargers the battery type range and manufacturer specific maximum charging currents have to be respected. As a rule for batteries of the PzS type range max. 1.5 x I5 should not be exceeded.
I5 is equivalent to the 5-hour discharge current, i.e. for a battery capacity of 100 Ah this current is 20 A. Additionally battery type range and manufacturer specific voltage must not be exceeded (see chapter 2.2). Thereby the temperature dependence has to be respected too.

The effectivity of an opportunity charge is lowered, if the opportunity charge is conducted before approx. 30 % depth of discharge is reached.

4.2. Temperature

The maximum limiting temperature (electrolyte temperature) is
+55 °C for flooded batteries (liquid electrolyte) and +45 °C for valve regulated batteries (immobilised electrolyte gel / AGM).

When opportunity charging with enhanced energy throughput (max. 1.2 x nominal capacity) between 2 complete charges, higher average battery temperatures compared to applications without occur.

Higher temperatures decrease the service life (see ZVEI leaflet "Considerations on the life of traction batteries").

In case of regular opportunity charges with a higher energy throughput as 1 x nominal capacity, change batteries are recommended.

Reasons for increased temperatures during opportunity charging are:

- Number and duration of the opportunity chargers per day
- The magnitude of the charging current
- Installation conditions in the industrial truck

For applications in which an increased battery temperature can be expected a temperature compensated charging regime is recommended. The correction factor is battery manufacturer and type range specific. The compliance of the limiting value listed before must be safeguarded in order to avoid damages of the battery.

4.3. Ventillation requirements

In order to prevent an accumulation of charging gases in the battery compartment, an equivalent ventilation cross section A [cm^2] must be existent for inlet and outlet of air.
For the calculation of the cross section in case of limitations to 2.4 Vpc (30°C) the following equation applies:

$$A=(28\times 0{,}05\times n\times I_{gas}\times C_5)/100$$

with:

n – the number of cells which are charged at the same time,

I_{gas} – the end of charge current [A] of 2A for IU charging in accordance with DIN EN 50272-3: 2003-05, table 1.

C_5 – 5-hour capacity [Ah]

The calculation for the exemplarily listed batteries gives the following ventilations cross sections (for in and outlet each):

A = 126 cm^2
for 24 V 3 PzS 375

A = 420 cm^2
for 48 V 5 PzS 625

A = 868 cm^2
for 80 V 5 PzS 775

For opportunity charges with standard chargers in charging stations and at charging positions always the safety requirements according to DIN EN 50272-3 have to be respected.

For non regulated chargers the covers of batteries, respectively the battery compartments have to be opened .

5. Operation requirements

For flooded battery systems of the PzS / PzB ranges, acid stratification, which is as well reducing the performance as the service life, has to be avoided. This can occur on multiple successive opportunity charges with higher energy throughput (> 80% Cn per day)

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