Fachverband Batterien

ZVEI: Die Elektroindustrie

ZVEI information leaflet No. 8e

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Service Life of Traction Batteries

1. General remarks

The efficiency of industrial electric trucks is influenced to a great degree by traction batteries and their usage.

Traction batteries are designed in general in such a way that they can supply an industrial truck with the required electrical energy over one shift.

The expected service life, respectively the endurance in cycles is determined by the design type, the selection of appropriate materials and the manufacturing quality.

Standard EN 60254-1 defines laboratory tests and test conditions in order to provide a comparative and neutral scale for the most important characteristics of traction batteries.

This applies e.g to:

- Comparability of products
- Test of the manufacturing quality
- Specifications of design tasks

As the result of laboratory tests according to this standard for traction batteries with positive tubular plates (PzS-cells according to EN 60254-2) typically 1500 cycles and for traction batteries with tubular plates and immobilized electrolyte (PzV-cells) 900 cycles are determined.

The cycle test comprises a defined series of charges and discharges.
The endurance in cycles test is deemed to be ended, when the measured capacity is less than 80% of the nominal capacity.

The endurance[*)] in cycles determined as described cannot readily be transferred to practical applications, because not all operational conditions that occur in practice can be mapped in the laboratory test.

For the estimation of the service life[*)] of a battery in the practical application the respective operational parameter have to be taken into consideration.

[*)] Definition of terms cf. ZVEI- leaflet No 23

2. Stress in practical operations

Mechanical

In contrast to laboratory tests the battery in practical operations is exposed additionally to mechanical stress, which affects all battery and cell components. Mechanical stress has a significant influence on the adherence and the electrical contact of the active masses in the grids.

Discharge

The endurance test in the laboratory is conducted with constant current. In contrast to this in the practical application exist dynamical varying current profiles.

While during laboratory tests the discharge is performed in a defined way, in practice it is not always ensured that the allowed depth of discharge of max. 80% of the nominal capacity is met.

Discharges >80 % are deep discharges with severe negative effects on the service life.

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

Charging

A further effect on the service life is given by the charging technology respectively the mode of operation.

Poorly adapted charging characteristics, obsolete charger technology and insufficient control characteristic lead to under or over charge.

Opportunity charge of the battery without electrolyte mixing or regular equalization charges result in acid stratification with enhanced corrosion and damaging of the mass.

Rapid charging with high energy throughput per day and very high charging currents leads to very high temperatures und thus to enhanced corrosion.

For opportunity and rapid charge operational advantages have to be weighed.

Industrial trucks with recuperation on braking and lowering loads lead to a higher energy throughput of the battery per shift.

Influence of high charging and discharging currents

High discharge currents and transient high charging currents from recuperation by regenerative braking and lowering of the industrial truck result in an inhomogeneous and over-proportional usage of the active masse. The consequent loss of active mass results in an accelerated aging of the battery.

Temperature

For the laboratory tests the temperatures are hold within narrow limits. In practice the average temperature deviates significantly from the nominal temperature of 30°C. Additionally there are temperature differences between the cells of the battery.

Higher temperatures have a strongly negative impact on the service life, because they accelerate side reactions like corrosion and ageing.

3. Remarks concerning valve regulated batteries

Valve regulated traction batteries of the PzV range with gel immobilized electrolyte at a depth of discharge of 60% of the nominal capacity achieve a comparable service life as PzS batteries at 80% depth of discharge (depending on the application and battery size according to the manufacturers' statement up to 80 % depth of discharge may be permitted).

4. Translation of battery service life to industrial truck operating hours

The service life of a battery calculated according to this information leaflet can be converted into operating hours of a battery as follows.

The calculation of the customary operational truck utilization time is done according to the VDI-guideline VDI 3960. It defines the following utilization time shares:

Utilization time (total)	100.0 %
Driver absent	20.0 %
Driver loading	8.5 %
Driver sitting	7.0 %
Runtime under load	64.5 %

For the recording of the utilization time of an industrial truck it should be strived for the goal to acquire the real operating time as reliable as possible, because only then the truck consumes energy and is subject to wear and tear.

Generally operating hour counters are used for this, which however can be set up differently.

For electrical industrial trucks **three different modes** for the operating hour counters are common:

(1) Operating hours are counted when the key switch is turned on and at minimum one motor is running. Only the effective load running time and thus thus the effective battery operating hours are counted.

The operating hour counter shows 100% of the run time under load.

(2) Operating hours are recorded if key switch and seat switch are turned on, i.e. operating hours are also recorded on standstill.

Value from experience: operating hours are equivalent to 110 % of the effective run time under load.

(3) Operating hours are only recorded if the key switch is activated (turned on) , i.e. operating are also recorded during standstill.

Experience value: The indicated operating hours are equivalent to 125 % of the effective run time under load.

Depending on the applied operating hour mode the following times are displayed at the operating hour counter at e.g. 240 shifts per year and 5hours run time[1] under load:

(1) 1200 hours,
(2) 1320 hours,
(3) 1500 hours

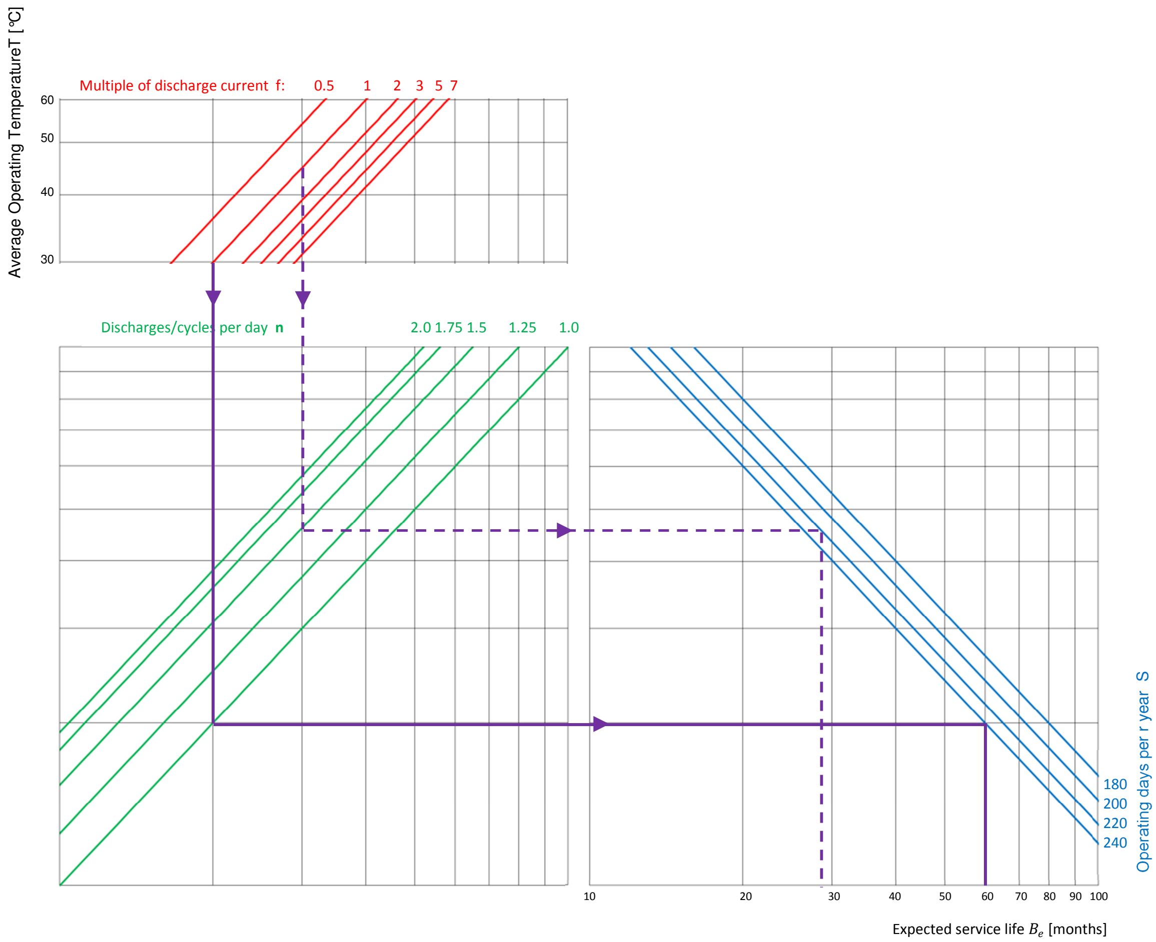
[1] The real time of energy supply usually is between 4 to 5 hours. The nominal capacity C_N of a traction battery for industrial trucks is referred to the five hour discharge and stated as C_5.

5. Example for the determination of service life for für PzS and PzV batteries

The two examples in the graph below illustrate how the diagram shall be applied.

	Example 1 (solid arrow)	Example 2 (dashed arrow)
Operation parameters	for PzS and PzV	for PzS
Average discharge current	1 x I_5 (A)	1 x I_5 (A)
Average operation temperature	30℃	45℃
Discharges/cycles per day	1	1.5
Operation days per year	240	220
Depth of discharge PzS	80%	80%
Depth of discharge PzV	60%	
Expected service life in month which can be read from the diagram	60	29

Along the lines of these examples the service life for other specific operational parameters can be determined from the graph.



For PzV batteries with 80% depth of discharge the expected service life shall be presumed to be 2/3 of the indicated value .

6. Template for the determination of the service life of PzS and PzV batteries

Note: The algorithm is only valid for operational temperatures T above the nominal temperature $T_N \geq 30$ °C

The applying maximum permissible operating temperature is 55 °C for PzS and 45 °C for PzV

$$B_e = \frac{E_N \times T_N \times M}{T \times [1 + \frac{7}{T_N} \times \ln f] \times n \times S}$$

B_e = Expected service life (with M=1 in years or with M=12 in month)

T = Average operating temperature

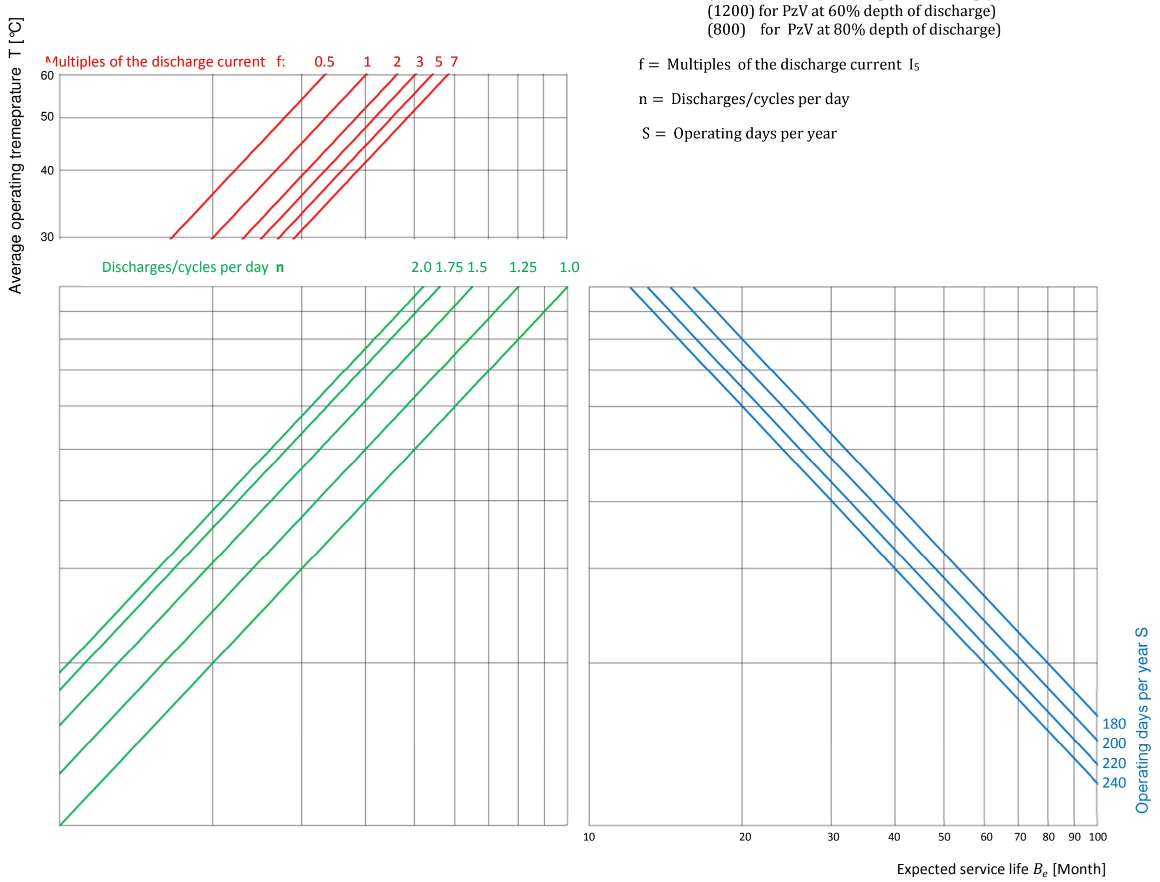
T_N = Nominal temperature (30°C)

E_N = Nominal energy throughput
(1200) for PzS at 80% depth of discharge)
(1200) for PzV at 60% depth of discharge)
(800) for PzV at 80% depth of discharge)

f = Multiples of the discharge current I_5

n = Discharges/cycles per day

S = Operating days per year



For PzV batteries with 80% depth of discharge the expected service life shall be presumed to be 2/3 of the indicated value.

ZVEI Die Elektroindustrie

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