ZVEI: Batterien

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Service life – Considerations for Stationary Batteries

1. General Information

Stationary batteries take over many functions of power supply in the daily life, which in all cases serve safety of human beings, production processes or data back-up. To ensure the permanence and reliability of these functions the knowledge about service life is very important. In accordance to DIN 40729 (Galvanic secondary cells, general terms and definitions) point 9.2 the service life is defined as follows:

Period of time, during which with a given load and by following the maintenance instructions, the specified limits of reliability characteristics will be fulfilled for all contemplated units (e.g. same type of batteries).

The service life of stationary batteries is mainly influenced by:

- the design
- the quality of used materials
- production quality
- application conditions
- maintenance

The first factors can be influenced by the manufacturer of the batteries, while the operation conditions and the maintenance are determined by the user.

Examples of parameters which can strongly influence and reduce service life are:

- **Increased operation temperatures**
  The service life is reduced by halve with every 10 K battery temperature increase above the nominal temperature of 20 °C

- **The temperature gradient within a battery**
  The temperature difference should not exceed 3 K.

- **Float voltage and its adaptation to temperature and discharge regime**
  Float voltages below regular lead to rapid capacity loss, which is irreversible because of sulfatation;
  Float voltages above regular leads to strong corrosion, gassing and water loss of the battery.

- **AC loads**
  AC currents with frequencies >30 Hz leads mainly to an increase of the battery temperature and as a consequence to higher water consumption and accelerated corrosion.
  AC currents with frequencies <30 Hz leads mainly to an insufficient state of charge (SOC) and cycling.

- **Operation mode (parallel stand by operation or buffer operation mode)**
  Buffer operation always leads to battery cycling; cycles accelerate ageing of the battery compared to parallel stand by operation.

- **Number of discharges**
  Frequent discharges (cyclic applications) leads to accelerated ageing.

- **Depth of Discharge (DOD)**
  Higher DOD results in accelerated ageing.

Results from accelerated life time tests done in labs cannot be simply transferred to expected service life. Therefore, the given figures are strongly based on these results and field experiences under comparable conditions.

The available discharge capacity of stationary batteries is changing during service life (see figure 1). Normally service life is defined as finished when capacity decreases below 80% of projected capacity.

The aging process of a battery still exists even in non-cyclic operation. This aging affects the service life in applications with higher discharge currents stronger than during discharges with lower currents.

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

Usually statements regarding service life refer to the nominal current over a 10 h discharge. The end of life criterion (80% of the projected bridging time) will be reached earlier in systems which are dimensioned for significantly higher currents (discharge <1h).

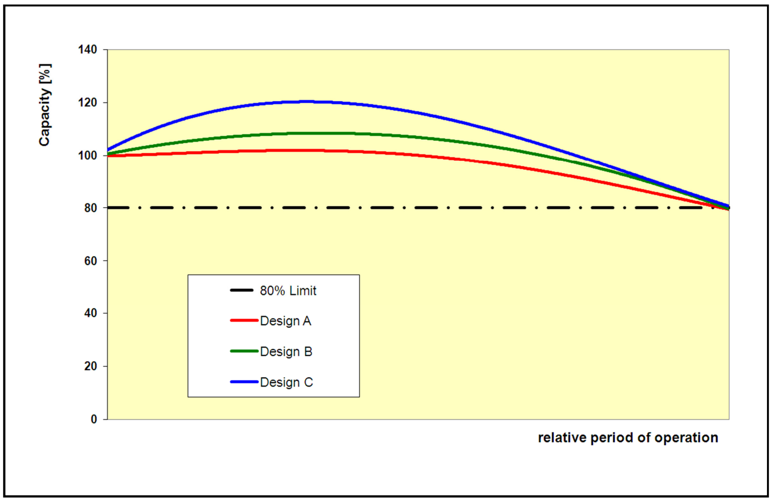

Figure 1: Typical characteristics of battery capacities over service life

2. Field experience values for the service life of standardised batteries

The service life of battery types are stated by the manufacturers, specified in accordance to applications and environmental conditions. For some standardised types experience data of service life are available which can be achieved under optimal application conditions:

OPzS-cells	DIN 40736	15 years
OPzS-block batteries	DIN 40737	13 years
GroE-cells	DIN 40738	18 years
OGi-block batteries	DIN 40739	12 years
OGi-cells	DIN 40734	14 years
OGiV-block batteries	DIN 40741, P1	12 years
OPzV-cells	DIN 40742	14 years
OPzV- block batteries	DIN 40744	13 years

Optimal operation conditions:

- **Operation mode** — Parallel stand by operation
- **Discharge** — maximum once per month
- **Discharge current** — nominal current
- **Depth of discharge (DOD)** — maximum 80 % of nominal capacity

- **Float voltage** — depends on battery design, published by manufacturer

- **Operating temperature** — 20℃ ± 2 K

- **AC – ripple I_{eff}** — should be lower than
  2 A / 100 Ah C10 for vented batteries
  and
  1 A / 100 Ah C10 for valve regulated batteries (VRLA)

- **Maintenance according to specific manuals and operational instructions**

3. Typical Failure Characteristics

The failure characteristics of modules are typically described by a bath tub diagram (figure 2). This curve characteristic is typical for batteries too.

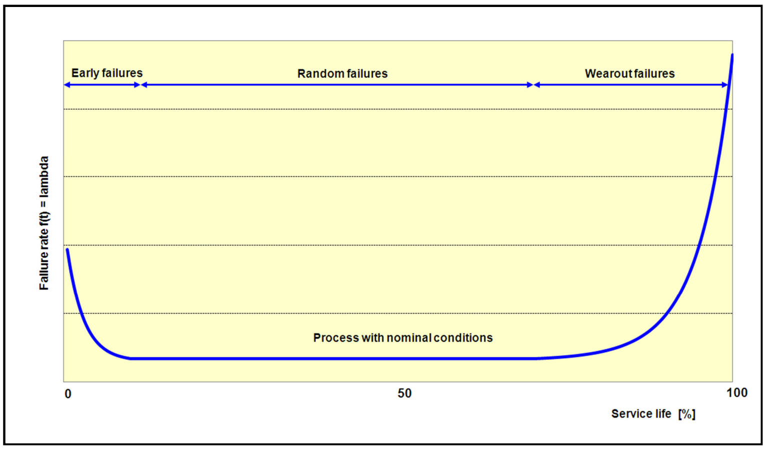

Figure 2: Failure characteristic of batteries (“bath tub diagram”)

The failure characteristic of a module over service life is shown in figure 2. It can be divided in 3 typical periods.

- **Period 1 — Early Failure**
  The failure rate in this period is mainly determined by failures during manufacturing the product and during installation/commissioning.
- **Period 2 — Random Failure**
  The failure rate in this period is mainly determined by operational conditions and therefore connected to stress factors (see chapter 4).
- **Period 3 — Failures by Ageing**
  This failure rate is determined by wearing down, that means the end of service life is achieved for a part of the whole battery.
  Start and rate of failures by ageing depends strongly on service and maintenance and therefore can not be influenced by the battery manufacturer; except a specific service contract exists. The reliability of the total system (total battery performance, dispersion range of single units) decreases at the end of this period exponentially. The replacement of the battery should therefore be carried out before this strong increase of failures occurs.

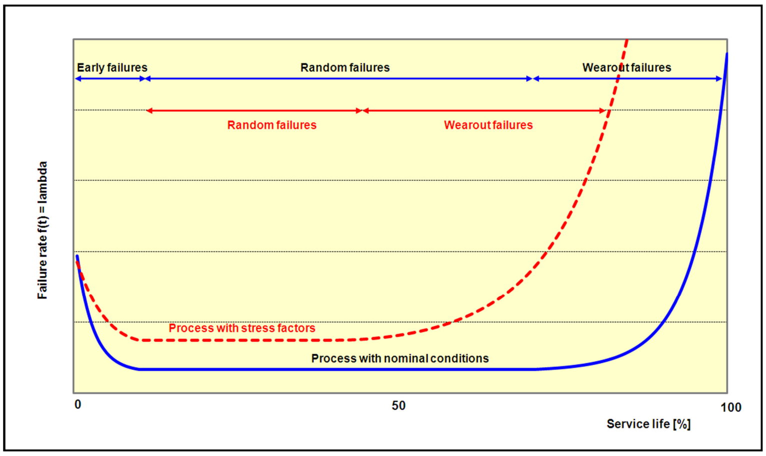

Figure 3: Failure characteristics under stress conditions

4. Influence of stress factors and maintenance on failure characteristics

Application related stress factors and the quality of maintenance influence strongly the duration of above mentioned 3 periods as well as the absolute level of the failure rate. Typical stress factors are already described in chapter 1.

The failure curve is shifting (see figure 3) in case of e.g. higher temperatures, insufficient maintenance, high AC-ripple or unsuitable float voltage.

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