TEMPERATURE EFFECT ON LIFE TIME

COMPARISON OF TUBULAR AND FLAT PLATE DESIGN

1. Introduction

In a mature design of lead acid batteries the service life of a cell is dependent only on the corrosion of the positive grid. Other failure mechanisms can be avoided by choosing the right design and the right material. Examples for avoidable failure mechanisms are

- improper pole bushing - where the growth of the positive grid results in cracking of the lid and the box or the crevice corrosion corrodes the pole completely within some years.
- improper alloy or improper casting - where the grid already contains cracks from the beginning or the corrosion acts prematurely on grain boundaries and deteriorates the grid within a few years.
- improper alloy and electrode design - where the float current is too high and watering intervals are less than 1 year under normal float conditions.
- **BAE** OPzS as a VLA tubular design and **BAE** ***OGi*** as a VLA flat plate design are mature products. Therefore their service life time is restricted only by the corrosion of the positive grid.

2. Temperature effect on the corrosion of the positive grid

Corrosion of the positive grid increases with temperature. The corrosion effect due to temperature is similar for all lead alloys and can be calculated using the Arrhenius approach (see below). This effect can be confirmed with accelerated life time testing. According to IEEE 535, one year of anticipated service life at 25°C can be simulated with an accelerated life-test of 20 days at 62.8°C.

Although the corrosion effect due to the increase with temperature is very similar for all lead alloys, the lifetime results will vary dependent upon the design features and the workmanship of the batteries. Thus, it is important how much lead is used for the positive grid. Are the grid wires thick with a large distance between grid wires, or are they thin with a small distance between wires? Tubular plates have no horizontal wires; the vertical spines can be made thicker as in comparable flat plates. High pressure casting (for tubular grids) reduces holes and voids in the grid cross section in comparison to gravity casting.

To get a life time evaluation of the different grid designs we followed a simple procedure:

To see the different life time of tubular and flat plate design we did an accelerated life time test (see BAE-Battcon paper 2006). Both designs were floated at 2.23V/cell at a temperature of 62.8°C. We checked the capacity at the3h-rate every 50 days and recorded the time until the capacity was reduced to 80% of the nominal value.

The results were as follows:

	OPzS	OGi
Tested lifetime result at 62.8°C	550 days	425 days
Corresponding lifetime at 25°C	27,5 years	21,3 years

ARRHENIUS APPROACH

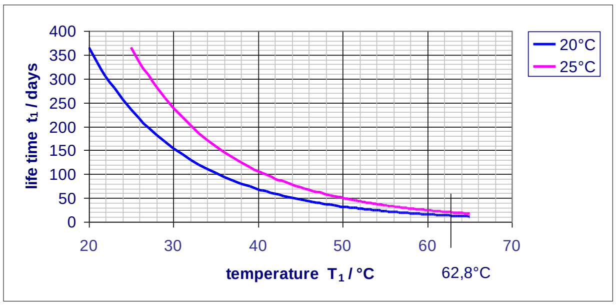
The rate of degradation of the positive grid of lead acid batteries at different temperatures obeys nicely the activation energy model of Arrhenius

$$t_1 = A * exp(E/RT_1)$$

where t_1 is the life time at the temperature T_1, E is the activation energy in cal/mole. R is the gas constant 1,987cal/mole/K. A is a factor, which will vanish, if two states with different temperatures are compared. The temperature dependence is ruled by one constant, the activation energy. We get a life time t_1 at the varying temperature T_1, having at the reference temperature T_2 a life time t_2 :

$$t_1 = t_2 * [exp(-E/RT_2) / exp(-E/RT_1)]$$

The activation energy can be derived from IEEE 535-1986:
365 days at 25°C correspond to 20 days at 62,8°C. These data result in an activation energy of 15,280 cal/mol according to the above formula. The graph below gives the life time also at intermediate temperatures.



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