The Design of VRLA Batteries for Successful Operation in a High-rate, Partial-state-of-charge Regime[1]

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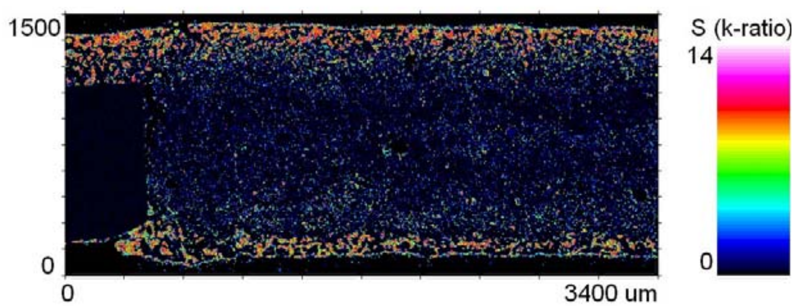
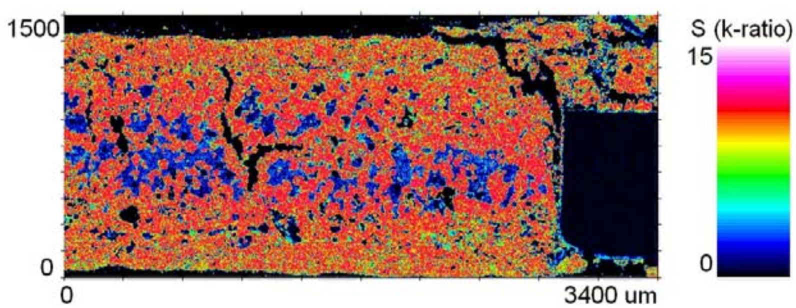
Lead–acid battery technology has provided a valuable means of energy storage for over 140 years. For most of the applications served during this time the charging of the battery has been at well below the 1-hour rate and the battery has been restored to a full state-of-charge frequently. Under these conditions, more often that not, the in-service life of the battery has been limited by processes that occur primarily at the positive plate (grid corrosion, active material shedding etc.).

Applications are now emerging in which rates of charge (as well as discharge) are required to be at very much higher rates. A major example is the battery for the new family of automobiles with a stop/start function and regenerative braking. The latter feature demands that the battery also must be operated at an intermediate-state-of-charge. Conventional lead-acid batteries (flooded or VRLA) operated under these conditions fail rather quickly due to an accumulation of lead sulfate on the negative plate (see Figure 1).



(a)



(b)

Figure. 1. Electron probe maps of sulfur distribution through a negative plate (a) after 1735 high-rate partial-state-of-charge cycles and (b) after 3191 high-rate partial-state-of-charge cycles.

Lead-acid batteries operated in other applications during which recharge takes place a very high rates will be prone to this type of failure unless precautions are taken to avoid it, either by battery design or by imposing appropriate limitations on the duty cycle.

The Advanced Lead-acid Battery Consortium (ALABC) technical program has undertaken an in-depth study of the failure mechanism involved in high-rate partial-state-of-charge (HRPSoC) operations and

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developed modifications to battery formulation designed to avoid these problems. It has been shown the battery grids must be designed to allow the charge and discharge current densities to be as uniform as possible over all the active material even that at the highest rates. One scheme for achieving this is to use a second current take off tab in on each grid. A second approach is to extend the current take off feature along the whole length of one side of the plate, as shown in Figure 2.

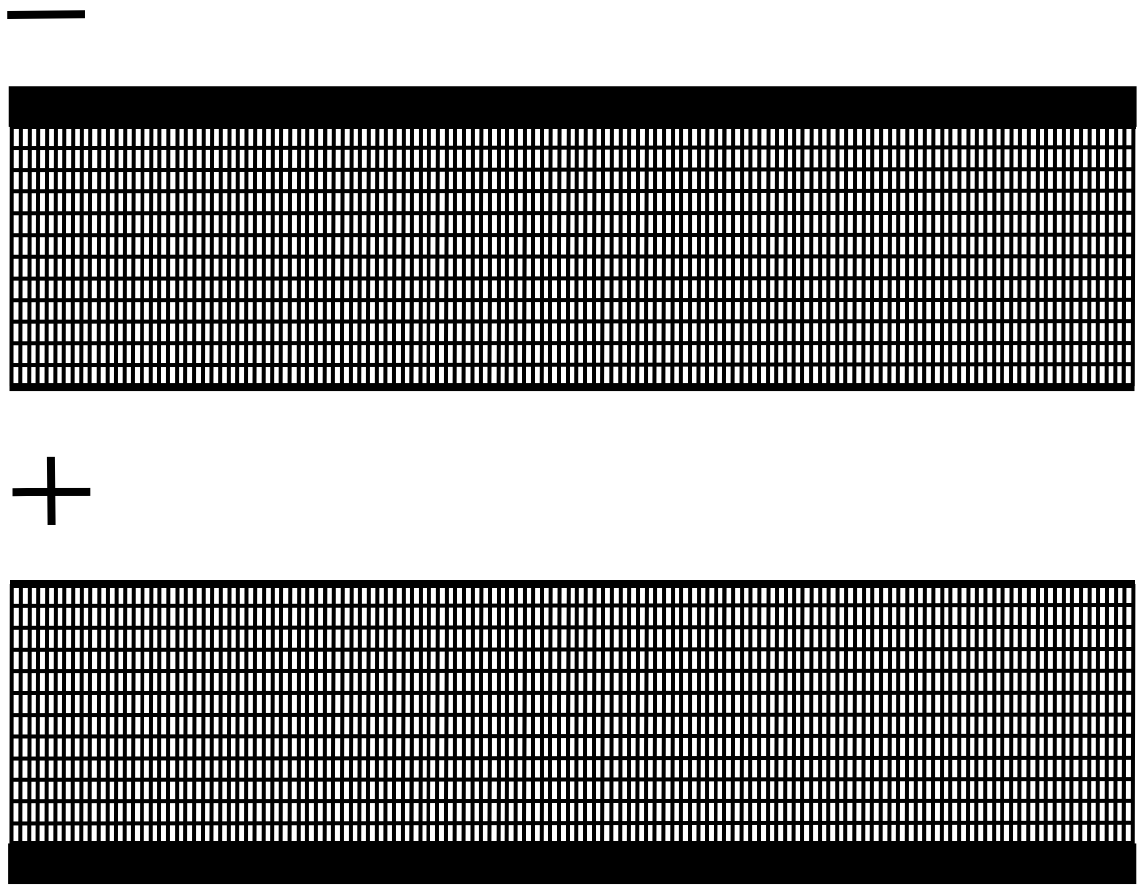

Figure 2 Electrode grids with extended tabs located at opposite ends of the electrodes [1].

Both these changes add some weight to the battery but this is more than compensated by the additional high-rate capacity that becomes available as a result of the improved current capability.

Markedly improved performance in HRPSoC duty is also achieved by altering the type and quantity of carbon included in the negative plate mix. For many years it has been customary for battery manufacturers to add 0.2 wt % of carbon black to the negative active material. For HRPSoC operation very significant benefit accrues as a result of the addition of 2 wt% of carbon. The extent of the benefit also depends on the type of carbon selected.

Reference

1. ALABC project N 4.2, Task 2, P. Baca, M. Calabek, P. Krivak, K. Micka.