Technical Communication

Connected Smart Energy Division

Influence of the cell orientation and discharge rate on the available capacity and voltage stability of a Lithium-Thionyl Chloride cell

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It must first be emphasized that cell orientation effects with bobbin Li-$SOCl_2$ cells, and therefore the Saft's LS cell-series, are only noticeable under a continuous discharge load combined with a high discharge rate. This situation may be encountered by customers in accelerated testing such as incoming inspection controls or in the framework of qualification of new battery configurations.

Please note that cell orientation in real battery use will never come into play and reduce battery lifetime. In the following is explained the fundamental mechanism behind this statement.

Since the active cathode material $SOCl_2$ is also the solvent of the electrolyte, it is progressively consumed during cell lifetime, and consequently dried out at end of discharge.

By construction, bobbin cells are not symmetric in bottom/top direction: there is a free space just beneath the top cover, which is used like a “reservoir” for part of the electrolyte (see figure 1). For small bobbins, it is the only available internal space, while for large bobbins there is one more located at the center of the cathodic collector.

Even though thionyl chloride is introduced in slight excess versus lithium quantity in the design of all Saft Li-$SOCl_2$ cells (anode-limited cells), starvation phenomenon will occur toward the end of discharge: the liquid electrolyte present in the “reservoir” has a relatively long capillary distance to cover before reaching the appropriate electrochemically active lithium sites, especially for small bobbin cells as mentioned above (Fig. 1).

This will enhance cell polarization at end of discharge and lead to 5-15% increased cell-to-cell capacity spread, **in following unfavorable conditions being met altogether**:

- AA, A mainly, C or D-sized bobbin cells,
- Continuous discharge current exceeding 0.5 mA/sq. cm,
- Temperature < 30°C,
- Cell motionless during the application,
- Cells discharged vertically upside down or in horizontal position.

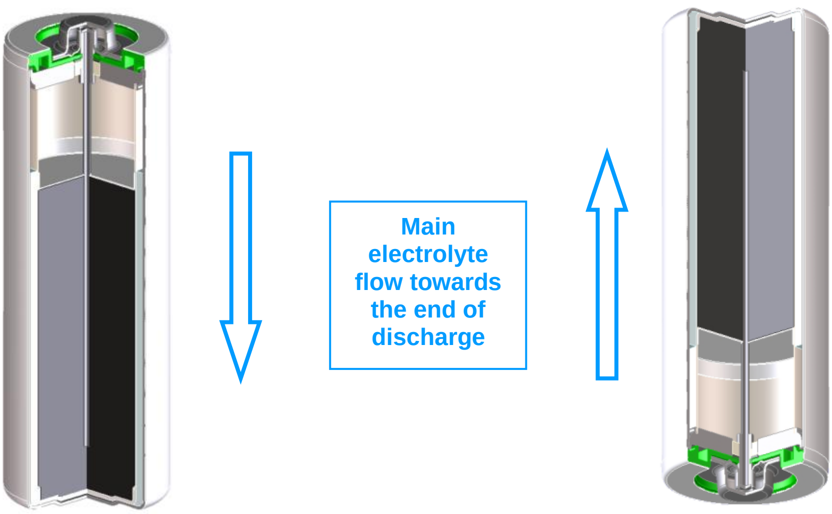

Figure 1: The (long) capillary path of the electrolyte within a small LS cell towards the end of discharge

Nevertheless, in field battery operation, i.e., in low-rate discharge with infrequent pulsing and/or at temperature above ambient, or submitted to movement at least once a day, and/or in horizontal or vertical upright position, kinetics of the electrochemical reaction is slow enough for the electrolyte to reach the reaction sites by capillary transport and there will be no concern.

Voltage stability after mid-discharge may also be impacted by cell orientation **in fast continuous discharge conditions**. This phenomenon is called “grassing effect”. It is also a consequence of electrolyte starvation within the pores of carbon support at the end of a high-rate continuous discharge.

Like explained in the above, for small LS cells the reservoir of electrolyte is located beneath the cover, i.e., at the bottom when the cell is in upside down position. As a consequence, the remaining liquid has to move up along the height of the cell by capillary transport within the pores of the separator and carbon support, in opposite direction versus gravity.

At the end of discharge, the liquid electrolyte in contact with the pores is not continuous but in droplet form due to the small quantity left inside the cell. The intermittent physical contact between the carbon pores and the liquid electrolyte, meaning “on/off” electrical contact within the call, is the main root cause of voltage oscillations or “grassing”. Basically, when the contact between the carbon pores and the electrolyte droplets is temporarily lost, voltage quickly goes down and when it is recovered the moment after (electrolyte goes back inside pores), the voltage goes up.
The low average discharge rate (1 000 times < threshold for a possible effect) and the long recovery time between high pulses, will enable the battery to work fine whatever its orientation.

Overall, even in applications using small bobbin cells for which the grassing effect is maximized among all Li-$SOCl_2$ designs, there is no concern in the field since the average discharge rates are low to very low (equivalent to several years of operation).

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