Safety characteristics for Tadiran TLI HT Cells.

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General

The aim of this document is to describe the safety characteristics of Tadiran’s rechargeable TLI1550HT and TLI1020HT cells. Based on these cells the safety characteristics of TLI1050HT cells that has the same electrochemical technology are evaluated. As a comparison, the safety characteristics of Tadiran current product TLI1550A will be introduced. In addition, the thermal stability of commercial Li-Ion cells available on the market will be described in comparison to Tadiran high temperature technology.

Tadiran Li-Ion Technology

Tadiran Li-Ion cells are hermetically sealed by GTMS (Glass To Metal Sealant). The cells are designed for long term operation (20Y) under high power conditions (up to 50C rate at RT) with thousands of stable cycles, all this at wide temperature range of -40 to 90C. The unique design and the high level of chemical stability give these cells also high level of safety.

TLI1550A is a standard AA size cell with 350mAh capacity. It can deliver up to 18W at RT and about 5W at extreme temperature of -40C. It can deliver thousands of cycles with minor capacity loss.

These cells are successfully pass many safety tests such as:

1. Short circuit tests at RT and 55C.
2. Temperature cycles -40 to 75C.
3. Impact.
5. Over charge and over discharge.
6. Hot box up to 130C.

For all these tests, no fire nor cell disassembly were observed. Also, no electrolyte leaks were observed (except impact/crush). At short circuit tests, max temperature measured on the cells surface exceeds 135C. For other tests (except hot box) maximum temperature was much lower.
Recently, new type of 4.1V TLI cells were develop at Tadiran. The max operating and exposure temperature for these cells were increased to 135C. These cells are designed for several applications includes automotive, trucking, outdoor sensors, oil-drilling and medical. The cells can withstand more than 100 standard autoclave sterilization cycles with minor capacity loss. For TLI1550HT cells (standard AA size) the available capacity is 500mAh. Operating and exposure temperature range is -40 to 135C. Hundreds of cycles are achieved with minor capacity loss. These cells were also subjected to many safety and abuse tests as will be described further, showing excellent safety and thermal stability behavior.

**Safety tests results**

1. Short test:  
   Figure 1 show tests results for short test conducted at 55C. The maximum peak current is 50A. Then, it was decreased to 22A continuous until the separator was shut down. The result was no fire, no cell assembly nor electrolyte leaking with max temperature of up to 125C.

![Figure 1: Short test at 55C for TLI1550HT Cells](image-url)
2. Temperature cycles:

Cells were subjected to 2 types of temperature cycles:

1. -40°C to 75°C as described in Figure 2.

![UN Temp cycle](image)

Figure 2: UN temperature cycles

2. 200 autoclave cycles up to 135°C Figure 3.
No safety event nor electrolyte leaking was observed due to the above temperature cycles.

3. Over discharge:

TLI1550HT cells were subjected to over-discharge tests under 5A. As it can be seen at Figure 4, cells reach minimum reversion voltage of -4V, then recovered towards zero. As a result, the cells were heated to max temperature of 80C and then cooled to room temperature. No safety event was observed.
5. Over Charge:

TLI1550HT cells were subjected to over-charge tests under 0.2A. The voltage of the power supply was limited to 12V.

As it can be seen at Figure 5, cells reaches maximum charge voltage of 5V, then stabilized. As a result, cells were heated to 40°C. This temperature was stable for 24h. No safety event was observed.

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6. Crush test:

TLI1550HT cells were subjected to crush tests. During the test, the cells were pressed under 13KN to 50% of the original thickness (See Picture 1). No safety event was observed despite the hard mechanical damage caused to the cells by this test.
7. **Hot box tests:**

Hot box test is one of the most significant tests for evaluation of the chemical stability of cell components. During this test, the cells are exposed to high temperature environment for several hours. Cell case temperature and oven temperature are continuously monitored. A difference between cell temperature and oven temperature is attributed to instability level of cell components instability of cell anode or cell cathode with the liquid electrolyte. Several Li-Ion cells were tested under hot box test to evaluate their thermal stability. Several Li-Ion cells were tested under hot box test to evaluate their thermal stability. TLI1550A cells were found to be stable upon 130°C. However, when tested at 170°C, thermal run-away was observed (Figure 6).
TLI1550HT cells were also subjected to the same test at 170C (Figure 7). As is can be seen, no thermal run-away was observed when cell temperature was followed the oven temperature indicating minor exothermic chemical reaction in the TLI1550HT cells was occurred.

As LFP chemistry is considered to be with high level of safety among several Li-Ion chemistries, 2 types of commercial Li-Ion LFP cells (14500 and 18650 sizes) were tested for comparison (Figure 8). As can be seen, thermal run-away/electrolyte leaking was observed in both type of cells.
Figure 7: Hot box test at 170C for TLI1550HT Cells

Figure 8: Hot box test at 170C for commercial Li-Ion LFP cells

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Recently, TLI1020HT cells were also developed. These cells are 10mm diameter and 20mm high with the same chemistry as for TLI1550HT cell (just smaller). The available capacity for these cells is 37mAh. These cells were passed successfully the same tests described for TLI1550HT. TLI1050 cells are similar to the TLI1020 cells with just a different high of 50mm instead of 20mm. Available capacity for this cell is 150mAh.

The cells will be subjected to the same tests as for TLI1550HT and TLI1020HT in the near future. It is expected that these cells will also successfully pass all the safety tests.