APPLICATION NOTE:

# EFFECT OF MECHANICAL NAIL PENETRATION ON BATTERY THERMAL STABILITY IN BTC

Two separate experiments were performed to determine the thermal stability of a 3-battery, Li-ion battery pack. The objective was to compare the stability of the battery when it is complete and undamaged with the result when the batteries were penetrated with a nail.

The result of the first test is shown below. This is with a normal, complete and undamaged battery pack and shows that the thermal stability is detected at a temperature of around 120°C. This is quite a low temperature but the results show that after detection of the runaway reaction, the temperature rises quite slowly and reaches a final figure of around 190°C, nearly 130 minutes after the heat release was detected.

The reaction ended by itself and hence at the end, a flat temperature trace can be seen. Eventually, the software automatically injects nitrogen into the BTC to start a cool-down.

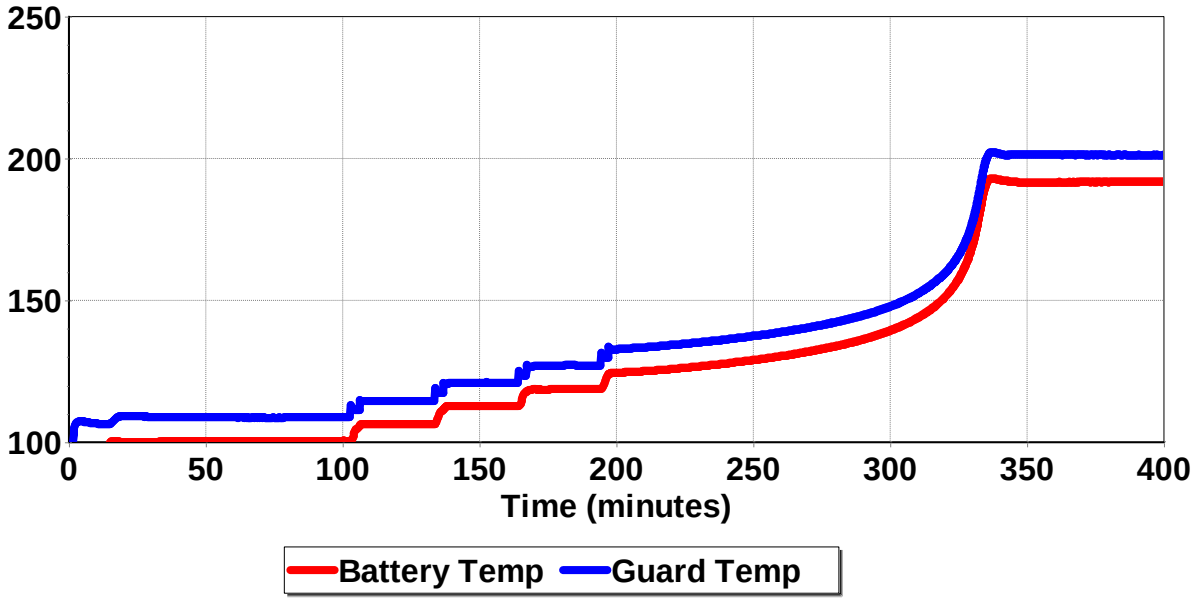


FIGURE 1. DATA FROM TESTING UNDAMAGED LI-ION BATTERY PACK

The second test was very similar except that the battery pack was purposely damaged by penetration with a large (5mm diameter) nail which was pushed through. The battery pack was placed on a steel

"tray" before the penetration and then the tray (and battery) were placed in the BTC to start the thermal stability test.

The results of this test are shown in the plot below where the results look very similar. The thermal stability problem is detected at almost the same temperature as for the undamaged battery – around 115 °C (instead of 125 °C in the last test).

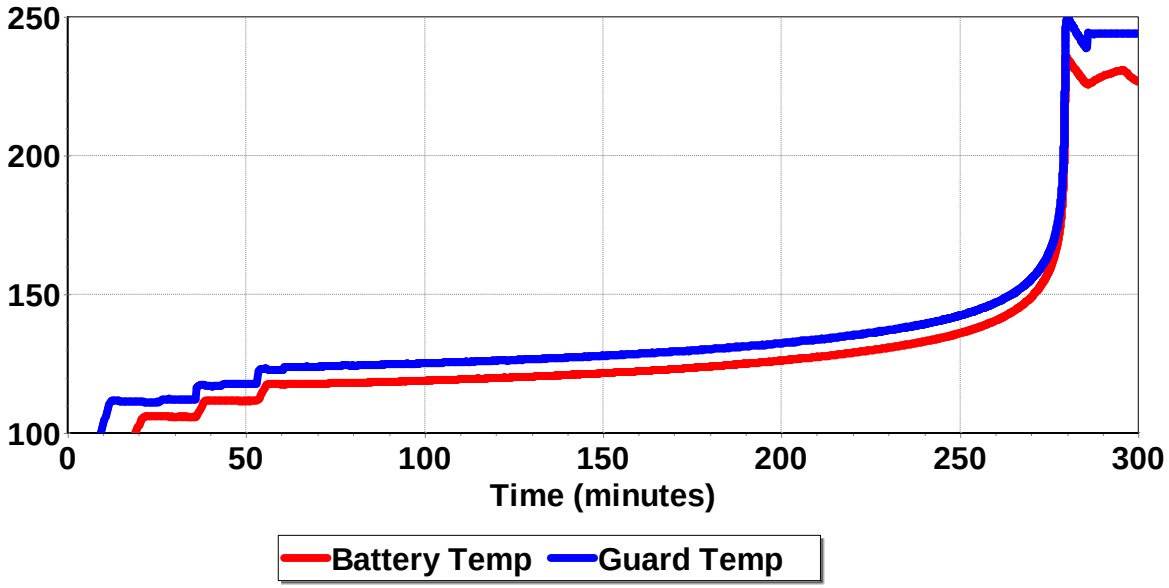


FIGURE 2. DATA FROM TESTING DAMAGED LI-ION BATTERY PACK

However, after this heat release starts, the thermal runaway reaches higher temperature than before. After a temperature of around 150 °C is reached, the thermal runaway is VERY fast – it takes only a few minutes to rise by around 100 °C and reach the temperature which triggers the safety shut-down. The recorded maximum (around 23 °5C) is not the true maximum that would have been reached without the emergency inert gas injection.

It should be noted however that tests with and without penetration does not always follow this trend. The consequences depend critically on the way in which the battery is damaged with is quite unpredictable. The results will depend on what is actually penetrated and how this affects the chemical nature of the battery.

FIGURE 3. DAMAGED BATTERY PACK AFTER THE TEST