Rapid Screening Device - RSD™
Technical Application Note 107
Battery Safety Testing

Introduction

The Accelerating Rate Calorimeter has been used extensively to study the stability of batteries and heat output from batteries under conditions of use and abuse. Much information is available: www.thtuk.com.

These applications have given insight into battery safety and have been used mainly in battery research. These tests can be time consuming and the instrument has a significant price tag. The RSD will not give quantitative data on such an array of test protocols, but can be applied to battery stability and safety. The RSD has advantages, it is more rapid in its operation, it is simpler to use and data analysis is more easily. In addition the RSD is a much lower cost instrument and it has broad versatility.

It is clear that there can be many applications of the RSD to battery safety studies. This is true especially where a fast turn round time is required. Here we report simply how the thermal stability of a Li-ion battery can be quantified in the RSD and how such testing can be extended. We also consider briefly what the potential use is for the RSD in the area of battery safety.

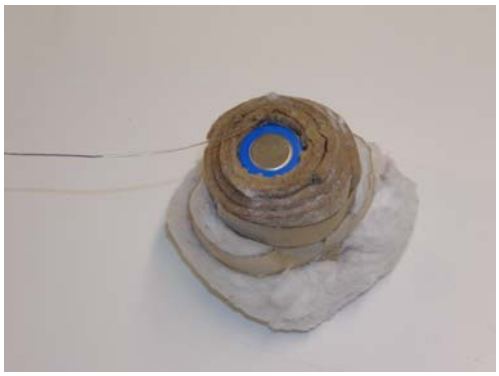
It should be noted that within the RSD the sample temperature should be measured within the sample. This is suitable for a chemical but not simple for a battery. To overcome this, in these tests the battery is enclosed within an insulating package. The RSD method utilises a temperature ramp or can be used isothermally. During a temperature ramp, when a sample is encased in insulation as here, the battery temperature will be well below that of the recirculating air calorimeter temperature. However, the battery is will still subject to the same temperature ramp.

Experimental

The ARC test was a standard heat-wait-seek test; 5ºC steps from 50ºC, an onset sensitivity of 0.02ºC/min and a wait time of 30 minutes. In this test the battery was supported in a small frame within the thermocouple held against the side by a metal band.

The batteries used here 18480 of weight 33 grams. Prior to testing they were charged at 1.5A to 4.1V and held at constant voltage until the charging current was less than 100 mA.

RSD tests were carried out with a temperature ramp of 2ºC/min from ambient. The thermocouple was held onto the battery by a metal band. The battery was then sealed in its insulating package. It was placed centrally in the RSD chamber. No pressure was observed in this test.



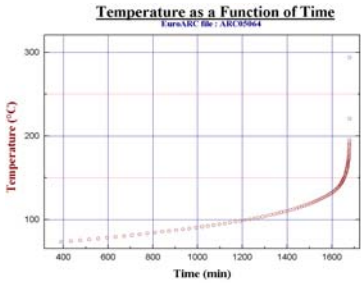
Rapid Screening Device - RSD™
Technical Application Note 107
Battery Safety Testing

Results

On the ARC the battery showed the heat output typical for charged Li-Ion batteries. An onset below 100°C was recorded, the temperature rate increasing until near 130°C where melting and shrinkage of the separator occurs. The temperature rate continued to accelerate and near 150°C there was release of electrolyte and some shorting within the battery.

The RSD at 2°C/min has shown onset at a higher temperature. This would be expected for a temperature ramped test. From the onset there is steady increase in heat output – as seen in the ARC. In addition the decrease in exothermicity due to separator melting is clearly shown. The heat release continues until very rapid heat output. This is probably at the time of venting of the electrolyte.

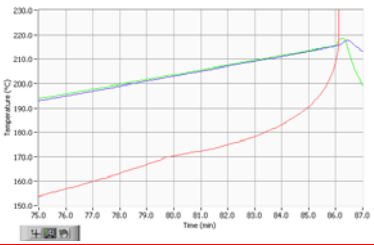
ARC Data



These and other tests not reported here give the conclusion that the RSD can be applied to battery testing. The data will give onset and increase in heat output with temperature. Detail of the decomposition can be seen.

RSD Data

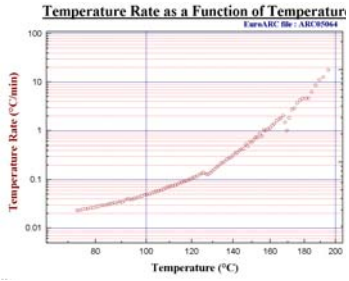
Temperature as a Function of Time



The key data presentation of the RSD is its ability to show data as difference between sample and reference. This is shown here (for temperature difference only) it allows high sensitivity of data presentation.

The RSD is an appropriate instrument for quality control or for rapid evaluation of battery stability. In normal use taking one battery per test, perhaps 6 or 7 tests could be carried out in one day. For higher throughput there is the potential of 4 or 5 batteries per test.

In addition and not reported here, tests can be carried out with the batteries linked to a Battery Cycler or other device. In this way during the test voltage could be measured during testing. There is the possibility to carry out tests during charging, over-voltage charging and shorting of the battery. Tests could be carried out in closed sample holders if pressure data was required.



Finally, the calorimeter internal volume and simple construction of the RSD allows for great flexibility and versatility in testing batteries of many shapes and sizes. The extraction capability of the RSD is very high and thus minimises noxious fumes and smoke.

Temperature Difference Between Battery and Reference as a Function of Reference Temperature (often corrected)