OVERVIEW OF ADVANCED SECONDARY BATTERY TESTING IN BRITAIN

J. L. SUDWORTH

Beta Research & Development Ltd., 50 Goodmoor Road, Sinfin, Derby DE2 9GN (U.K.)

Introduction

Advanced secondary battery testing in Britain appears to be restricted to sodium–sulphur batteries and lithium–aluminium/iron sulphide batteries. In both cases, the main application for which the batteries are being developed is traction.

Sodium–sulphur cells

Sodium–sulphur cells are being tested at two companies, Chloride Silent Power, Ltd., at Runcorn, and Beta Research and Development, Ltd., at Derby. At CSPL each cell is discharged at 330 °C through a resistive load at the three hour rate to an open circuit voltage of 1.76 V, which corresponds to complete discharge, *i.e.*, to the composition Na_2S_3. Recharge is accomplished by connecting the cell to a 2.8 V supply via a resistor which limits the current to $C/5$. The time limit for charge is five hours, giving three cycles per day.

The test regime used at Beta R & D Ltd., is similar to the one described above but the rates of charge and discharge are higher. The nominal cell temperature is 350 °C but this increases to 390 °C on discharge. The cells are discharged through a resistor at the 2 C rate for a maximum of 20 min and, after an open circuit period of 30 s, are charged by connecting them to a 3 V supply. The resistance of the circuit results in the charge current being limited to a maximum of 1.5 C. The charge time is limited to 30 min. The cells discharge to an instantaneous open circuit voltage of 1.7 V which corresponds to full discharge to Na_2S_3.

Mean time to failure of certain groups of cells is around 3000 cycles for both organisations. Cell resistance and capacity are also monitored. In the case of the high rate tests at Beta R & D this is done at lower rates to avoid heating effects. The cell resistance quoted is the effective resistance, *i.e.*, cell open circuit less load voltage divided by current, near the beginning of discharge.

Some testing using constant current is carried out. In these tests the cells are cycled between set voltage limits.

Sodium–sulphur batteries

At Beta R & D batteries are tested in the laboratory by charging at constant current and discharging through a resistor load bank. Track and field testing in vehicles is also undertaken and several batteries with capacities up to 25 kW h have been tested in electric cars on both test tracks and on the public roads. Data collected on these tests are limited to the current and voltage of the series connected chains which make up the battery, and to temperatures within the battery.

Non-electrical testing

In addition to life testing and performance tests, two non-electrical test methods are used — safety testing, and shock and vibration testing.

Safety tests are applied to any new cell designs and take the form of deliberate failure of the cell by overcharge, overdischarge or crushing. For a sodium–sulphur cell, overcharge is the most convenient method since the impedance of the cell increases rapidly at top of charge, and the β-alumina electrolyte fractures when the cell voltage rises to a certain value which may be between 8 and 70 V depending upon the design and history of the cell. After failure, current is passed through the cell at the $C/2$ rate for a period of 20 min. The criterion for a safe cell is that no reactants should escape from the cell.

Shock and vibration testing is done using hydraulically-actuated vibration test equipment which can apply sinusoidal or square waves of controlled frequency and amplitude to cells and batteries. The *g*-forces applied in these tests can also be controlled. Initial tests are usually carried out on cold cells containing liquids of similar densities and viscosities to the cell reactants, and these are followed up by tests on hot cells.

Lithium–aluminium/iron sulphide batteries

Cells

These cells are tested at the Admiralty Research Establishment at Holton Heath, Dorset. Constant current cycling is used, to 100% depth of discharge. Most of the tests are carried out at higher rates than would be expected for the application, *i.e.*, two to three hour discharge rate and five hour charge rate. The capacity of the cells tested varies from 6 A h up to 1000 A h, and the number of cycles per day varies from one to three.

Automatic data logging is used for data collection and stored data are accessible by computer.

Batteries

Batteries are cycled automatically using the same test regime as for cells. In addition, performance testing is carried out. With this system, charge balance in batteries is an important factor and these tests are aimed at detecting cells which get out of balance.