Battery Assembly Guidelines for Lithium, Lithium-Ion and Lithium Polymer Cells and Batteries Subject to UN T1 - T8 Testing

International transportation regulations require that the following tests be performed on all primary lithium, and rechargeable lithium ion and lithium polymer cells and batteries. Below each test description are general battery assembly guidelines to be considered by battery designers and assemblers to increase the likelihood of their battery designs passing the respective tests.

NOTE: The information provided herein is intended only as a guide. Following these guidelines does not assure that a cell or battery will pass the respective tests the first time. The ability to pass the tests is highly dependent on the use of proper battery design and assembly techniques and may sometimes require design modifications and multiple attempts.

Test T1: Altitude Simulation

Purpose

Simulates air transport under low-pressure conditions. Store at 11.6 kPa or less for 6 hours at 20°C.

Requirement

Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Guidelines

This vacuum test reduces the external pressure, thus increasing the likelihood of exposing potential cell leakage. Although most crimp-sealed cells can pass this test, welded, hermetically sealed cells will provide better leakage and out-gassing resistance.

Test T2: Thermal Test

Purpose

Assesses cell and battery seal integrity and internal electrical connections using thermal cycling to simulate rapid and extreme temperature changes. Perform 10 cycles between 75°C and -40°C, 6 hours per cycle with no more than 30 minutes between cycles, and then observe for 24 hours.

Requirement

Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Guidelines

The high temperature portion of this test increases the internal pressure of the cell and can expose potential cell leakage. Although most crimp-sealed cells can pass this test, welded, hermetically sealed cells will provide better leakage and out-gassing resistance.

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Test T3: Vibration

Purpose
Simulates vibration during transport. Sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz in 15 minutes. This cycle must be repeated 12 times for a total of 3 hours for each of three mutually perpendicular mounting positions of the cell or battery.

Requirement
Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Guidelines
This is a very aggressive test, more severe than some military-specification vibration tests. In order to increase the likelihood of passing this test, cells contained within a battery should be assembled in such a way as to prevent inter-cell movement that can result in cell interconnection tab breakage. Cells contained within a battery case should be prevented from moving within the case. Various types of potting materials and sealing compounds can be used for this purpose, and care must be taken to prevent blockage of cell safety vents. Additionally, circuit boards, components mounted on the boards and wires should be designed and sufficiently secured within the battery case to withstand the severe vibration forces associated with this test.

Test T4: Shock

Purpose
Simulates possible impacts during transport. Half-sine shock of peak acceleration of 150-G and pulse duration of 6 milliseconds. Each cell or battery must be subjected to 3 shocks in the positive direction and 3 shocks in the negative direction of three mutually perpendicular mounting positions for a total of 18 shocks.

Requirement
Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Guidelines
As with the vibration test, in order to increase the likelihood of passing this test, cells contained within a battery must be assembled in such a way as to prevent inter-cell movement that can result in cell interconnection tab breakage. Cells contained within a battery case should be prevented from moving within the case. Various types of potting materials and sealing compounds can be used for this purpose, and care must be taken to prevent blockage of cell safety vents. Additionally, circuit boards, components mounted on the boards and wires should be designed and sufficiently secured within the battery case to withstand the severe shock forces associated with this test.

Test T5: External Short Circuit

Procedure
Simulates an external short circuit. After stabilizing at 55°C apply an external resistance of less than 0.1 ohm for 1 hour and then observe for 6 hours.

Requirement
Cells and batteries meet this requirement if their external temperature does not exceed 170° C and there is no disassembly, no rupture and no fire within 6 hours of this test.

Guidelines
To pass this test cells and batteries must contain safety features that limit the current flow when the cells / batteries are short-circuited. Cells should contain a current limiting device (safety shutdown separator or a fuse) and a safety vent. Batteries should be fused or designed with a device that limits excessive current flow.

Test T6: Impact

Procedure
Simulates an impact. Place a 15.8 mm diameter bar across the sample and then drop a 9.1 kg mass from a height of 61 cm on to the bar, and then observe for 6 hours.

Requirement
Cells and component cells meet this requirement if their external temperature does not exceed 170° C and there is no disassembly and no fire within 6 hours of this test.

Guidelines
To meet the impact requirements cells and batteries should be designed with a robust outer case that prevents gross internal cell deformation that leads to the creation of an internal short circuit. Cells with safety shutdown separator tend to perform better under the impact test.

Test T7: Overcharge

Procedure
Evaluates the ability of a rechargeable battery to withstand overcharge. Charge at twice the manufacturer's recommended maximum continuous charge current for 24 hours, and then observe for 7 days.

Requirement
Rechargeable batteries meet this requirement if there is no disassembly and no fire within 7 days of the test.

Guidelines
In order to pass the overcharge test batteries should be designed with protection circuitry that limits current flow into the cells when the maximum allowable cell voltage is obtained.

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Test T8: Forced Discharge

Procedure

Evaluates the ability of a primary or a rechargeable cell to withstand forced discharge. Force discharge at an initial current equal to the maximum discharge current specified by the manufacturer, and then observe for 7 days.

Requirement

Primary or rechargeable cells meet this requirement if there is no disassembly and no fire within 7 days of the test.

Guidelines

In order to meet the forced discharge requirements cells should be designed with a method to minimize the heat generated by a cell that is placed in a forced discharge state. This is typically accomplished through a cell's electrode design.

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