

- ⊖ HOME
- ⊖ BATTERIES
- ⊖ BATTERY FINDER
- ⊖ DURACELL IN ACTION
- ⊖ CARE & DISPOSAL
- ⊕ TECHNICAL/OEM
 - Overview
 - Primary Systems
 - Overview
 - Alkaline Manganese Dioxide
 - Lithium Manganese Dioxide
 - Zinc Air
 - Silver Oxide
 - Rechargeable Systems
 - Multi-chemistry Tech.
 - System Comparisons
 - Design Tools
 - Contact Duracell OEM

TECHNICAL/OEM

Primary Systems

Lithium Manganese Dioxide

[OVERVIEW](#) | [TECHNICAL BULLETIN](#) | [PRODUCT SPECIFICATION SUMMARY](#) | [DATA SHEETS](#)

TECHNICAL BULLETIN Safety and Reliability



print

[Print this page](#)

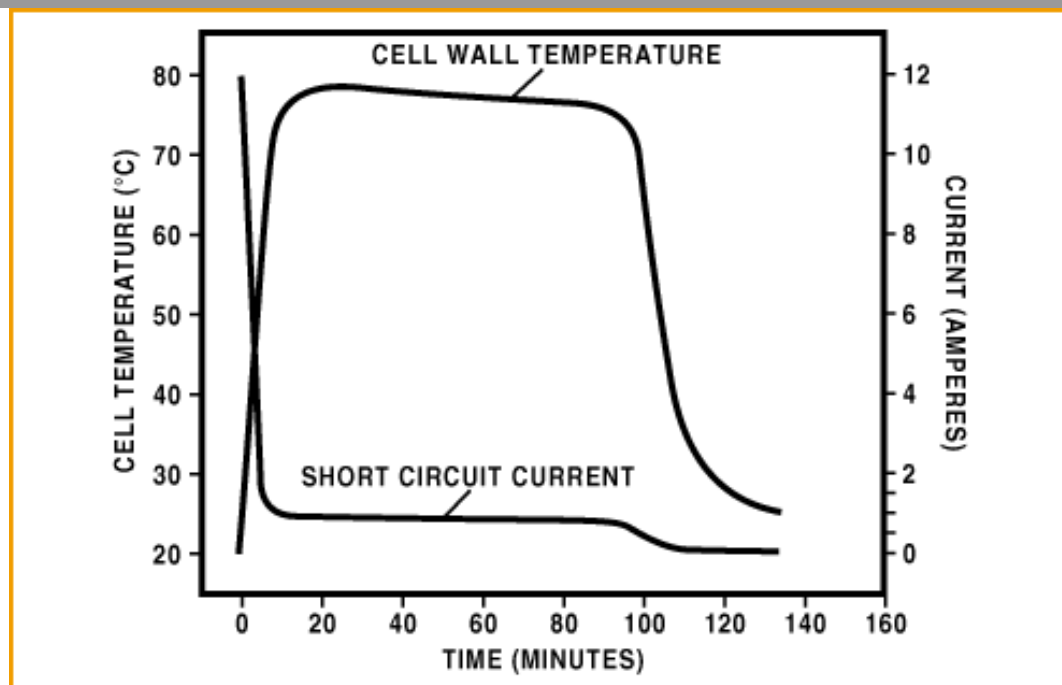
Safety Design Features of High Rate Cells

- **Current and Thermal Protection System**

Spiral-wound lithium cells are capable of delivering high current output due to the high surface area of the wound electrodes. To ensure safe operation, manufacturers of high rate cells normally require the use of protective devices, such as electrical fuses to limit the amount of current which can be drawn from the battery or thermal switches to cut off the discharge if a battery reaches high temperatures during use. These devices provide good protection against electrical abuse. However, they can also be troublesome--fuses must be replaced when blown, protective devices can create dimensional problems when battery size is critical, and protective devices increase battery costs.

Duracell was the first to design a resettable current and thermal protection system called a PTC (Positive Temperature Coefficient) device into its high rate cells. This integral safety device eliminates the need for electrical fuses or thermal devices to protect the battery against short circuits or discharge at currents above design limits. Under normal operating conditions, the PTC device does not impair cell performance. However, when a cell is short-circuited or discharged above design limits, the PTC device causes the cell's internal resistance to increase substantially limiting the amount of current which can be drawn from the cell and keeping the internal temperature of the cell well within safe limits.

Figure 8.1.1 : Short circuit of a DURACELL DL2/3A cell.



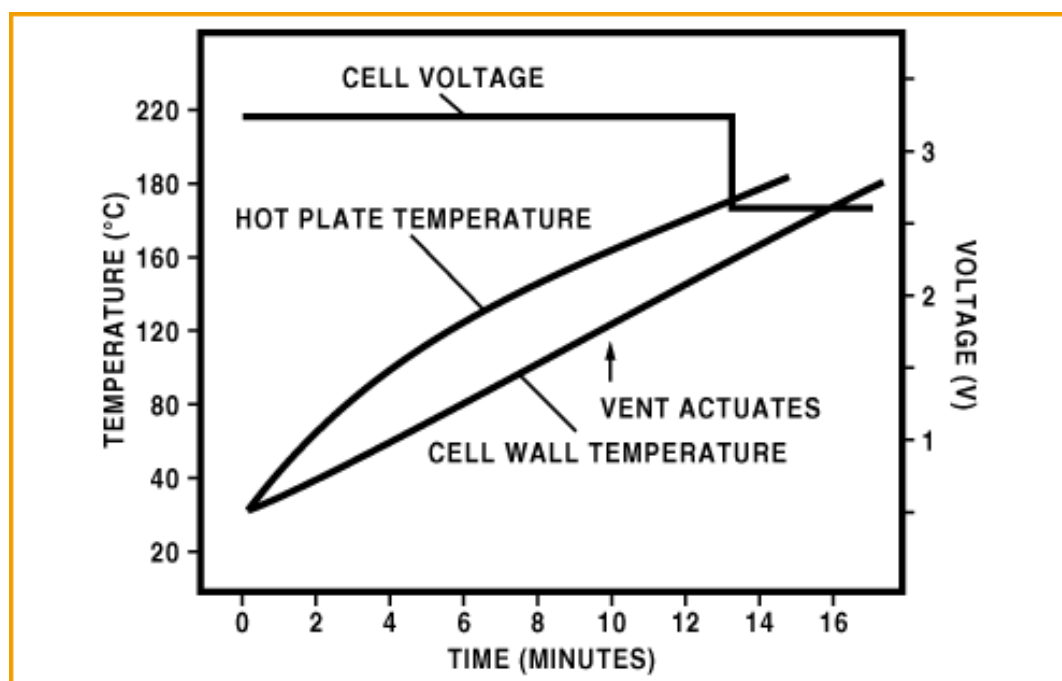
Cell temperature under abusive conditions is a gauge by which safety can often be measured, particularly with lithium batteries. It is necessary to maintain cell temperatures below the melting point of lithium, 180.5°C (357°F), to ensure safety

- **Safety Vent**

The safety vent in DURACELL high rate Li/MnO₂ cells serves as a back-up safety device. In instances of electrical abuse, such as heavy-duty discharge or accidental short-circuiting, the PTC device overrides the safety vent. In instances of severe mechanical abuse, the vent provides a safe means of releasing internal pressure and prevents the cell from reaching excessively high temperatures.

As internal pressure builds, a plastic laminate vent membrane is punctured by a vent spike incorporated in the cell top. This provides a safe release of internal pressure and prevents a potentially dangerous rupture of the cell casing. The safety vent in this Li/MnO₂ cell is designed to operate when the internal cell temperature reaches approximately 125°C (257°F). The internal pressure at the time of venting is around 40 psi.

Figure 8.1.2 : Heat test of a DURACELL DL2/3A cell.



- **Underwriters Laboratories Recognition**

DURACELL Li/MnO₂ cells are recognized under the Component Program of Underwriters Laboratories, Inc. (UL). To receive component recognition, UL requires that lithium batteries pass a number of tests during which the batteries are exposed to abusive environmental, mechanical and electrical conditions.

Complete details on the UL findings in testing the high rate, spiral-wound DURACELL DL2/3A cell as well as additional tests performed by Duracell are available upon [request](#). As a result of these tests, the DL2/3A cell and batteries comprised of this cell type, e.g., DL123A, DL223A, DL223AR, DL223AR are recognized for user-replaceable and technician-replaceable applications per UL File MH12538.

Underwriters Laboratories Recognition

DURACELL Li/MnO₂ cells are recognized under the Component Program of Underwriters Laboratories, Inc. (UL). To receive component recognition, UL requires that lithium batteries pass a number of tests during which the batteries are exposed to abusive environmental, mechanical and electrical conditions.

The following details UL findings in testing the high rate, spiral-wound DURACELL® DL2/3A cell. As a result of these tests, the DL2/3A cell and batteries comprised of this cell type, e.g., DL123A, DL223A, DL223AR, DL223AR are recognized for user-replaceable and technician-replaceable applications per UL File MH12538.

UL Test Methods and Results:

Sample Conditioning Tests

- **Oven Exposure Test**

Batteries were exposed for 90 days in an air convection oven at 71°C (160°F).

Results: No visible change.

- **Temperature Cycling Test**

Batteries were exposed to ten cycles from -54°C (-65°F) to 71°C (160°F) The batteries were exposed to each temperature for periods of 16 hours with 8 hour periods at room temperature between each exposure.

Results: No visible change.

- **Partial Discharge Test**

Cells were discharged to one third and two-thirds of their rated capacities. The cells were discharged by connecting the terminals of the cells through resistors selected to give the desired discharge in a 60-day interval. Cells were discharged at room temperature and also during exposure at 71°C (160°F).

Results: No visible change.

Environmental Tests

- **Humidity Test**

The batteries were exposed to high humidity conditions in a chamber having controlled temperature and humidity. The temperature in the chamber was raised to 65°C (149°F) and the relative humidity to 90-100 percent over a period of 2 hours and these conditions were maintained for 6 hours. The temperature of the chamber was then reduced to 30°C (86°F) in 16 hours while maintaining a relative humidity of at least 85 percent. This procedure was repeated for a total of 10 cycles.

Results: No signs of visible changes other than a slight discoloration of the metal casings.

- **Heating Test**

Batteries were heated in an oven to a temperature of 160°C (320°F). The rate of heating was controlled and ranged from 1°C/minute to 11°C/minute.

Results: No ruptures, fires or explosions.

Mechanical Tests

- **Vibration Test**

This method calls for the application of simple harmonic motion with an amplitude of 0.03 in. (0.06 in. maximum excursion). The frequency was varied at the rate of 1 hertz/mm. between 10 and 55 hertz and return in not less than 90 nor more than 100 minutes. Each cell was tested in two mutually perpendicular directions.

Results: No changes observed.

- **Drop Test**

Tests were conducted on batteries previously tested in the Vibration Test. Each cell was dropped nine times, in random orientation, from a height of 158cm (6 feet) onto a concrete floor..

Results: No changes observed.

Electrical Tests

- **Short-Circuit Test**

The cells were shorted by connecting the positive and negative terminals with a short length of copper wire. Tests were conducted at room temperature and at 60°C (140°F).

Results: There were no signs of case bulging, leakage or any other visible changes. The maximum temperature measured on the exterior surface was 144°C (291°F) for the tests at room temperature and 143°C (289°F) for the tests at 60°C (140°F).

- **Forced Discharge and Recharging Test**

The cells were force-discharged at up to 12 mA by connecting them in series with a 12 V DC power supply. The current was controlled by connecting a resistor of appropriate size in series with the cells. After being force-discharged for 24-210 hours, the cells were physically reversed and subjected to a recharging current of up to 40 mA for an additional 24-210 hours. Additional cells were tested first in the charging mode and then reversed and force-discharged.

Results: No signs of case bulging, leakage or any other visible changes.

UL Abuse Tests for User Replacement

- **Flat Plate Crush Tests**

The cells were crushed between two flat surfaces. In these tests, the cells were positioned with their long axis parallel to the flat surfaces. The force was applied by means of a hydraulic ram, and the cells were crushed until a reading of 3000 psi was obtained on the pressure gauge on the hydraulic ram. The temperature on the exterior surface of the metal cell casing was monitored.

Results: The maximum cell temperature measured on the exterior of the cell casing of any of the cells tested was 38°C (100°F). No explosions, sparks or flames were observed. After the cells were removed from the hydraulic ram, the temperature of the cell casings was found to rise to 65°C (149°F).

- **Impact Test**

The cells were placed on a flat concrete surface with the long axis of the cell parallel to the flat surface. A cylindrical bar having a radius of curvature of 5/16 in. was positioned on the cell with the long axis perpendicular to the long axis of the cell. A 20 lb. weight was raised by means of a rope and pulley and dropped from a height of 2 feet onto the 5/16 in. cylindrical bar. The temperature on the exterior surface of the metal cell casing was monitored.

Results: The maximum cell casing temperature reached as a result of the test was 98°C (208°F). No explosions, sparks or flames were obtained. After the test, when the battery was removed from the test equipment, the battery temperature rose to a maximum of 118°C (244°F).

- **Fire Exposure Test**

The battery was exposed to fire by placing it horizontally on a steel wire mesh screen having 20 openings per inch (25.4 mm) and a wire diameter of 0.017 inch (0.43 mm). The screen was mounted 1 1/2 inches (38.1 mm) above a 1 1/2-inch diameter laboratory Meeker burner fueled by propane gas.

Results: The battery met the standards established by the Underwriters Laboratories for this test.

Additional Mechanical Abuse Tests

Duracell regularly performs abuse tests in addition to those tests detailed in the Underwriters Laboratories Recognition section. The following are results of other mechanical abuse tests performed on the DURACELL DL2/3A.

- **Penetration Test**

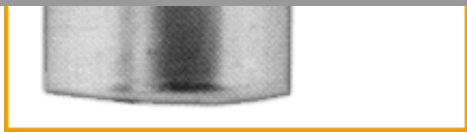
Cells were breached deliberately to various depths of penetration with a sharp metal spike of 0.065 inches (1.65 mm) in diameter by 0.730 inches (18.5mm) in length. (See Figure 8.3.1.)

Results:

1. No fire.
2. No explosion.
3. Cell short-circuit occurred.
4. Leakage of electrolyte occurred.



Figure 8.3.1 Nail penetration test



- **Saw Test**

Cells were held in a vise, sawed in half, and the two sections then dropped into water (See Figure 8.3.2.)

Results:

1. No fire.
2. No explosion.



Figure 8.3.2 Saw test

- **Immersion Test**

Cells were immersed in water and a 5-percent-by-weight salt solution.

Results:

1. No leakage of electrolyte.
2. No fires.
3. No explosion.
4. Rusting occurred over time, especially in the salt solution.

Caution:

In illustrating these tests, Duracell does not intend to suggest that similar abuse testing be performed on DURACELL Li/MnO₂ batteries or any other manufacturer's lithium batteries. As discussed throughout this site, all lithium batteries are not the same. Performing these tests in the manner described in this section or other abuse tests could result in fires or rupture of some batteries and serious personal injury and property damage.