Frequently Asked Questions (FAQ)

General electrical performance

renata batteries

Which values of open circuit voltage do lithium cells typically show?

The CR-type coin cells, based on the lithium/manganese dioxide electrochemical system, have a nominal voltage of 3 V. In practice, a fresh lithium cell will typically show an OCV (Open Circuit Voltage) between 3.15-3.35 V. This range of values is intended for measurements performed at room temperature; in fact, the OCV values depend on the temperature of the measurement.

After storage periods the cells may also show values outside this range, due to ageing effects (see the recommended storage conditions for lithium coin cells, also reported in this document).

What is the internal resistance of a cell? How does it affect the performance of the cell?

From an electrical point of view, a cell is a combination of an energy source and a resistance. The internal resistance (Ri) is a key parameter for a cell, as it determines its high-power capability (i.e. its ability of delivering its energy in a short time). The internal resistance reduces the useful voltage in applications and leads to internal heat, thus loss of energy, which increases with the square of the current.

The internal resistance of lithium cell is a sum of both ohmic contributions and of resistive contributions coming from electrochemical phenomena taking place during the discharge of the cell. By accurate selection and quality control of materials, Renata manufacturing process minimizes the resistive factors contributing to the internal resistance of the lithium cells.

As the internal resistance includes a number of resistive contributions coming from electrochemical phenomena, each of them being characterised by a time constant, the value of internal resistance is pretty much depending from the measuring method and conditions. A simple and inexpensive method for measuring the Ri is to apply a resistive load (R1) to the cell and to measure the value of the cell voltage under load (CCV, Closed Circuit Voltage). The internal resistance is then calculated as:

Ri = (OCV - CCV) x R1 / CCV.

Does the internal resistance changes with time, or during the cell discharge?

Generally speaking, there is a limited, physiological increase of the internal resistance of a primary cell during its service-life. In the case of lithium coin cells, the normal increase during the cell discharge is due both to ohmic factors (the distance between the electrodes increases during discharge) and to electrochemical phenomena taking place at the lithium anode (growing of interface films between lithium metal and electrolyte solution).

The increase of the overall internal resistance with increasing discharge level is reported in the figure below.

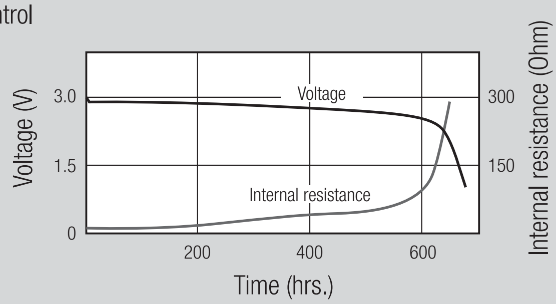

Figure 1 Characteristic curve[1] of a CR2450N cell. Discharge load: R1=3.32 kOhm. Measurement of internal resistance during discharge: by applying the load R2=150 Ohm for 1s, every 3 hrs.

1) This curve is intended as typical data and not as cell specification.

The ageing of the cells at normal conditions (i.e. room temperature, max. 40% of relative humidity) will also lead to other physiological increases of the internal resistance, due to normal ageing phenomena taking place at the electrodes. Though of limited extent, these types of increases of the internal resistance are normally to be expected and must be also taken into account, when designing a new application.

Exposing the cells to elevated temperatures, then, can lead to further grow of the passivation films at the anode, with an additional increase of internal resistance. Furthermore, increasing the temperature above 70°C can cause the internal resistance to abnormally increase (because of electrolyte leakages and degradation phenomena). Abuse conditions such as discharge at elevated currents and short-circuit can also increase the internal resistance abnormally, because of the deterioration of cell internal components.

Which is the voltage drop of the lithium cell during current pulse?

The voltage drop during a current pulse (ΔV) is the difference between the cell voltage just before applying the pulse (Voltage-high, V_1) and the cell voltage during the pulse (Voltage-low, V_2):

$$\Delta V = V_2 - V_1$$

It is also expressed by the formula:

$$\Delta V = Ri \times I_{peak},$$

where Ri (internal resistance) depends on the cell type and dimensions. In addition, the value of Ri depends on the temperature and on the discharge level of the cell (see related section about internal resistance). Therefore the voltage drop of the cell will be strongly affected by the temperature and by the cell's discharge level.

From the above reported formula it also follows that the voltage drop strictly depends on the applied pulse itself-particularly on the value of the pulse-current (I_{peak}). The voltage drop is also affected by the other parameters that define a pulse-load: the pulse duration (i.e. how long the pulse current I_{peak} is applied), the pulse period (i.e. the time between two subsequent pulses), the frequency with which the pulse trains occur (i.e. how often the pulse trains are applied to the battery) and -eventually- the basis-current (i.e. the current applied between two pulse trains). The last three pulse parameters affect the voltage drop during pulse, because their settings affect the value of the cell voltage just before applying the pulse (V_1).

An example of voltage and internal resistance behaviour during a pulse discharge is reported below (Figure 2).

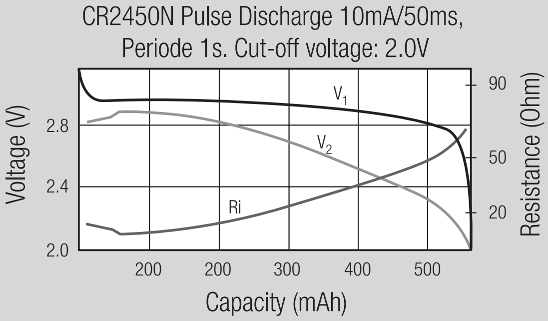

Figure 2: Pulse-current discharge characteristics[1] of the CR2450N cell.

1) This curve is intended as typical data and not as cell specification.

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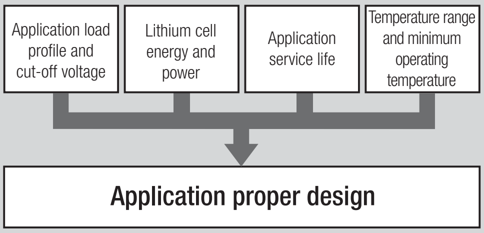
What is the maximum pulse current the lithium coin cells can handle?

There are no specified limits for the peak current value in pulse applications. Instead, current limits can be defined by means of a series of factors and practical considerations related to the electrical application, like the load profile, the cut-off voltage and the targeted service-life of the cell in the application. Electrical applications are normally regulated by a voltage threshold (cut-off voltage), under which the applications miss the required electric energy to work and therefore will shut-down. The cell is the energy/voltage source in the application; when the voltage during a pulse is lower than the cut-off voltage, the application will shut down. A proper design of the electrical application in terms of electrical load and cut-off voltage, combined with the choice of the cell of right energy and power characteristics, are of paramount importance in order to achieve the targeted service-life of the application. The mutual relation that links application characteristics, cell performances and targeted application services is graphically illustrated below.

Consult Renata experts in order to calculate and select the cell with the right characteristics for your application and achieve your goal!



What is the shortest time period for testing the behaviour of batteries?

It is common to perform accelerated tests to prove the lifetime of the battery in the application or to test the performance of different batteries. According to IEC 60086-1 it is recommended to discharge the battery for a period of approx. 30 days. With the standard discharge current given on page 7 of this Designer's Guide one achieves 100% of the nominal capacity within these 30 days.

However, also expedited test are possible when the resulting capacity decrease is taken into consideration. The limit of the average discharge current is the max. continuous discharge current given and explained on page 7. It is not recommended to perform tests with currents beyond this limit because the results may not be typical or they could be misleading. Li/MnO_2 batteries are designed to supply low currents for several years. Therefore, test results are rather random when discharging the batteries in very short time periods with high currents.

Frequently Asked Questions (FAQ)

Influence of temperature on electrical performance

The operating temperatures of lithium coin cells are given on page 7. Below –30°C the pulse current performance of the cells is significantly reduced, due to the increased internal resistance.

Ambient temperatures over the given max. operating temperature may be possible for a short period of time. Please ask Renata experts for advice on this matter.

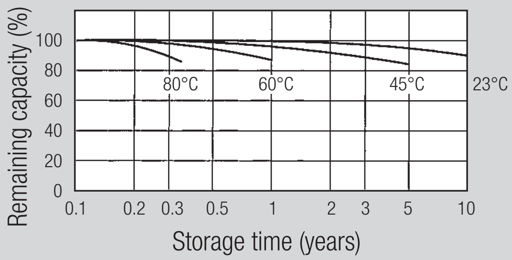
Has high temperature any detrimental effect on the cell performance?
Increasing temperature to values above room temperature will increase the rate of self-discharge, reducing the available cell capacity – thus shortening both the service-life and the shelf-life. The self-discharge of a cell is due to parasitic reactions taking place at the electrodes, consuming the electroactive material. As for every reaction, the rate of these processes is function of temperature. A simple "rule of thumb" to determine the self-discharge at a given temperature is the following: the rate of self-discharge increases of a factor 2 for every 10 degrees Celsius of temperature increase from room temperature (20°C). Given that at room temperature the rate of self-discharge of lithium coin cells is 1% of capacity loss per year, at 40°C (for example) the self-discharge rate will be:

$1\% \times 2^{(40-20)/10} = 1\% \times 2^2 = 4\%$ of capacity loss/year.

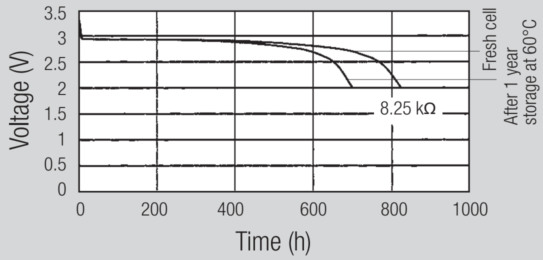
In addition to self-discharge considerations, the maximum storing and operating temperature for the lithium coin cells must not exceed the given max. operating temperature, in order to avoid any electrolyte leakages, leading to reductions of cell functionality.

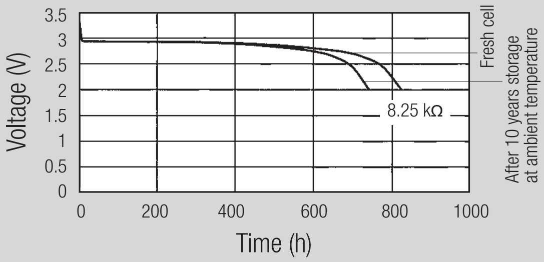
Characteristics

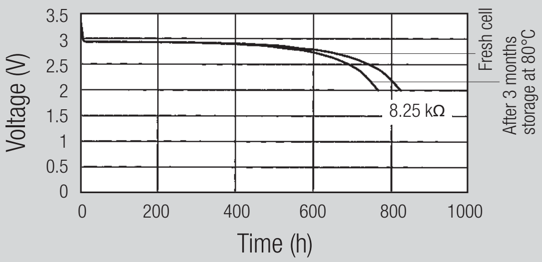
Shelf life (temperature / time)



Storage characteristics (CR2430)







Has low temperature any detrimental effect on the cell performance?
Generally speaking, the performances of a cell at low temperature are reduced because of the decreased conductivity of the electrolyte, which leads to an increase of internal resistance. As a consequence, the ability of the cell to deliver high power is reduced. Especially when designing an application with high power demand (high current consumption, like pulse-loads), this factor must be carefully taken into account.

Frequently Asked Questions (FAQ)

Influence of storage / ageing on electrical performance

Which are the recommended storage conditions for lithium coin cells?
The normal storage of lithium coin cells is made at temperature between +10°C and +25°C, never exceeding +30°C (also according to IEC 60086-1). In this way the maximum shelf-life (i.e. max. retention of cell performances after storage periods) of lithium coin cells is achieved. Storage temperatures above room temperature will increase the rate of self-discharge, reducing the available capacity of the cell. Humidity above 95% R.H. and below 40% R.H. should also be avoided for sustained periods, as these extremes are detrimental to batteries.

Storing the cells at low temperature is also suggested, but attention must be paid when transferring the cells to warmer environments, because of the possibility of having water condensing on to the cells (risk of short-circuits).

Influence of contact material

Which contact materials are recommended?
Recommended contact materials:

- Gold plating – provides the most reliable metal to metal contact under all environmental conditions.
- Solid nickel – provides excellent resistance to environmental corrosion.
- Nickel-clad stainless steel – performs almost as well as solid nickel.
- Nickel plated stainless steel – also a reliable metal to metal contact (also used for RENATA's battery holders SMTU/HU series).
- Inconel alloy – provides good electrical conductivity and corrosion resistance.

Never use tin plated contacts since in high humidity and polluted environments sulfides can form on the material and creep through pores in the coating.

Which contact force and design ensure best electrical performance and reliability?
The contact force of the contacts should be between 2 and 10N (ca. 200 to 1000 gf).

Contact design: It is important that contacts apply sufficient pressure to hold the battery firmly in place and prevent electrical disconnections (even under shock conditions). Contacts must be able to resist permanent set. Furthermore, two contact points guarantee more reliability than only one.

General FAQs

Can batteries undergo washing processes?
Please use non-conductive cleaning solutions for the PCB washing process. In conductive solutions, the batteries are short-circuited, causing discharge, voltage drop and possibly deterioration of the cell performance. Use cleaning solutions that do not attack the polypropylene cell gasket.

Are Renata lithium cells certified in terms of safety?
The safety of Renata cells is certified by Underwriters Laboratories Inc., Northbrook/IL/USA, under the file number MH14002. See also: *www.renata.com/content/3vlithium/tech_safety.php* and the Safety Section in this Guide.