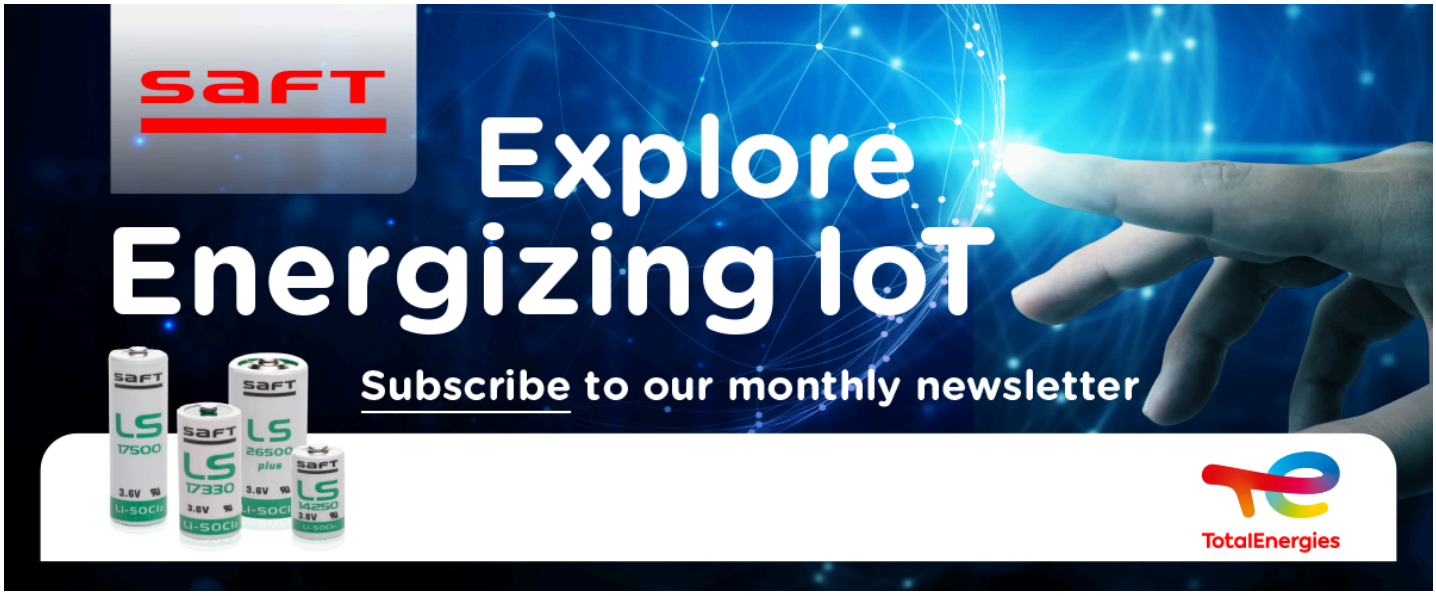
ALL ABOUT BATTERIES - Isabelle Sourmey - Application Engineer at Saft Connected Energy Division - January 13, 2022

Charging your lithium-ion batteries: 5 expert tips for a longer lifespan



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Industrial grade lithium-ion batteries powering your remote or portable devices offer ruggedized design and high energy density for a long lifetime, even under extreme temperatures. Their longevity is directly related to the way the battery is charged, discharged and the operating temperatu

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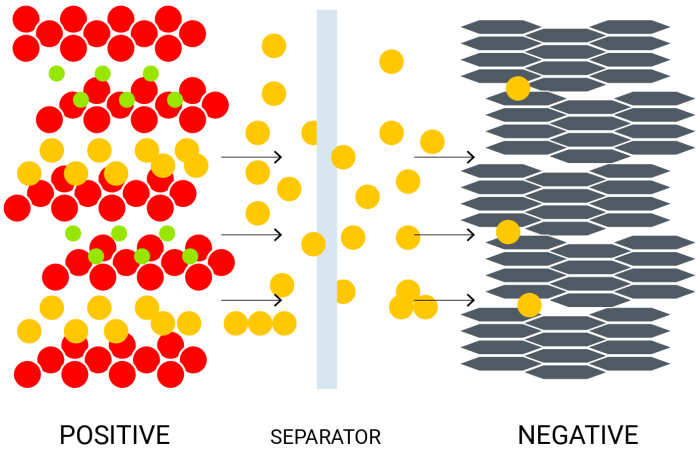
In this article, we will explain how these batteries work and share our 5 top tips on how to charge your industrial-grade lithium-ion batteries to optimize their lifespan. You'll find out **how balancing charging speed and rate is key for industrial applications**, just as it is for your mobiles, laptops or e-bikes.
Read on…

Top tip 1: Understand the battery language

Lithium-ion batteries are made of two electrodes: a positive one, and a negative one. When you charge or discharge your battery, electrons are going outside the battery through the electrical current and ions are flowing from one electrode to the other. **It is like both electrodes are breathing, exchanging ions in and out.**



When the battery provides current, electrons are moving from the anode to the cathode outside the battery. Applying **reverse current** allows the battery to recharge itself: the electrons are sent back to the anode and, the lithium ions re-intercalate themselves in the cathode. **This restores the battery's capacity**. The whole charging/discharging process is defined as a cycle. **The number of cycles that your battery can perform varies depending on the manufacturing process, the chemical components, and the actual usage.**

The capacity of a rechargeable battery is measured in Ah. Saft MP 176065 xtd boasts a 5.6 Ah capacity for example, which means that 5.6 A can be delivered in an hour at 25°C, over a cycle.

This capacity is being directly influenced by:

1. **The charging and discharging rate of the battery called the C rate.** Charge and discharge currents are typically expressed in fractions or multiples of the C rate: A C charge/discharge means that you will charge or discharge the battery in an hour. A C/2 charge/discharge takes two hours, a 2C charge/discharge takes 30 minutes, etc. Saft's MP 176065 xtd C rate is 5.6A. A C/2 charging at 2.8A would take approx. 2 hours.
2. **The voltage level that reflects the charge level:** in our MP 176065 xtd example above, a 4.2V indicates a full charge, a 2.7V indicates that the battery is completely discharged (cut-off voltage).
3. **The charging, discharging and operating temperature.**
4. **Multiple cycles:** with time, the battery loses capacity due to the physical and chemical degradation of the electrodes, and the electrolyte.

A good management of the depth of discharge (DoD —the percentage of the capacity which has been removed from the fully charged battery) **and of the maximum charging voltage** can also enhance the number of cycles that the battery will be able to perform and therefore, its operating life.

This article focuses on the charging best practices but we'll go through the discharging ones in our next article.

Top tip 2: Respect a CCCV charging process, especially when on floating mode (the charger is your best friend)

Charging a lithium-ion battery is not that simple. **The charger you will select has here a key role as the way you will set up parameters impacts your battery lifetime. Don't just plug it on any power supply** nor use a charger designed for another technology (Nickel-Cadmium or Lead), if you don't want to face safety issues.

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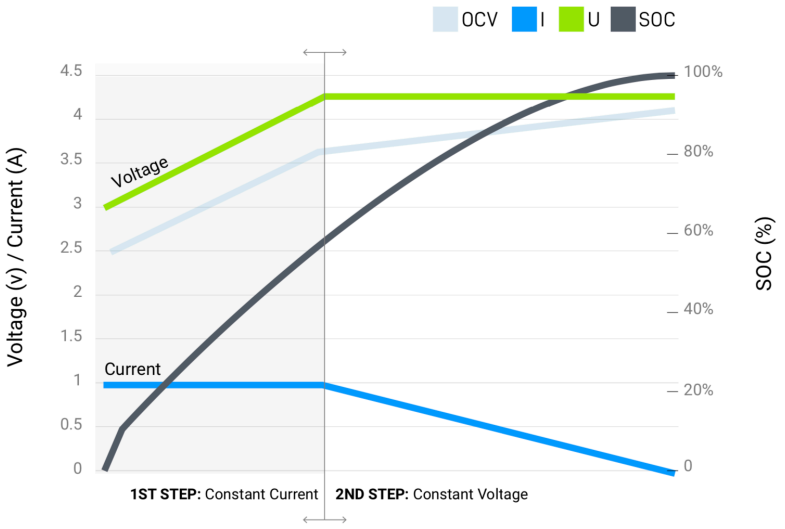
Charging properly a lithium-ion battery requires 2 steps: **Constant Current (CC) followed by Constant Voltage (CV) charging**. A CC charge is first applied to bring the voltage up to the end-of-charge voltage level. You might even decide to reduce the target voltage to preserve the electrode. Once the desired voltage is reached, CV charging begins and the current decreases. When the current is too low, the charge is finished, and the current must be removed.
For instance, to bring your MP 176065 xtd back to its 4.2V end-of-charge voltage, you can apply a 5.6A current. When reaching 4.2V, you maintain this voltage level by slowly decreasing the current to 100 mA or less and then stop it. You may also decide to reach 4.1V only, thus preserving the electrodes' elasticity and increasing the battery's lifetime.

The capacity of the battery depends directly on the end-of-charge voltage so lowering the voltage will lower the battery capacity. **You'll have to find the right trade-off between the autonomy needed, the minimum voltage at which your device can operate and the longevity of the battery.** Leaving a battery on a permanent charge under a floating current after the CV mode during the charging process is called the **floating mode**. Solar panel is a typical example of a floating mode application.

Most manufacturers don't recommend the floating mode as it damages the battery over time. Li-ion chemistry does not need to be maintained thanks to its low self-discharge level. Moreover, **if the battery design does not have the right safeguards, maintaining a charge rate into a fully charged cell could lead to overcharged it and an explosion.**
Saft's xtd range is specifically designed to operate in floating mode in safe conditions with a limited aging on a wide temperature range.



LI-ION CHARGING PROCESS CC/CV

Top tip 3: Carefully design your BMS (your other best friend)

Whichever the application, Li-Ion cells must be associated with electronics. This key electronic component is called a Battery Management System (BMS). The mandatory safety features interrupt the discharge/charge to protect the battery against overvoltage or undervoltage. The BMS checks the temperature and disconnects the battery to avoid overheating.

The BMS can also incorporate electronics optimizing a homogeneous charge between each cell in the battery pack (**balancing**). In a battery associating several cells connected in series, after a while in the field, cells from the pack will age differently. Without this balancing feature in the BMS, the most aged cell of the pack will age faster than the other. As the life duration of the pack is directly related to that most aged cell, **a good balancing system will improve the battery's lifespan.**

The BMS can be tailored to your use case. Some can display the **State of Charge** and the **State of Health** (ex: 85% of State of health means that the battery's capacity has decreased by 15% since the beginning of its life —an interesting indication as **it is understood that a 30% loss of the original capacity means the battery is reaching the end of its chemical life and replacement time is close**).

Top tip 4: Lower your charging C rate

At low charging speed (C/2, C/5 or even less), the lithium ions are intercalating themselves smoothly in the graphite sheets, without damaging the electrodes.
When the charge rate increases, this intercalation gets harder and harder. **If the rate is too strong,** Lithium ions have no time to penetrate the electrode properly and just deposit on its surface, which causes **the battery to age prematurely.**

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Fast charging rates like 4C or 10C are possible, for example for mobile or electric vehicles batteries, but the electrode constructions are different, and the expected lifespan is shorter.

Depending on how much time your application needs to be recharged and your use case, **you'll need to find the right trade-off between the necessary charging time and speed and the aging of the battery.** A C/50 charging rate is better for the electrodes but not every application can afford more than 50 hours charging time! A 2C charging time (30m) is possible but will accelerate the aging of the battery.
Therefore, Saft recommends limiting the charge rate of its MP range to C or less.

Top tip 5: Control the charging temperature

Most Li-Ion batteries use graphite type material in one electrode. An elevated charging temperature provokes the exfoliation of the graphite sheets which hastens permanent capacity loss in the battery. This phenomenon can be aggravated when associated to a high charging rate: the charging current increases the temperature and causes an acceleration of the exfoliation phenomenon.

A high voltage level coupled to a high temperature causes the electrochemistry to generate gases inside the cell which accelerates chemistry ageing. Depending on the cell construction, high temperatures can also generate cell swelling. Such a deformation can cause safety hazards when the battery casing or device location have not been designed to support it. **Make sure not to exceed the limits set by the battery manufacturer, or — for example— put a cell on full charge for an extended amount of time in an overheated car in the height of summer!**

If the battery design does not include the mandatory safeguards to avoid overcharge, over-discharge and over temperature, a cell internal temperature higher than 130°C could lead to a thermal runaway.

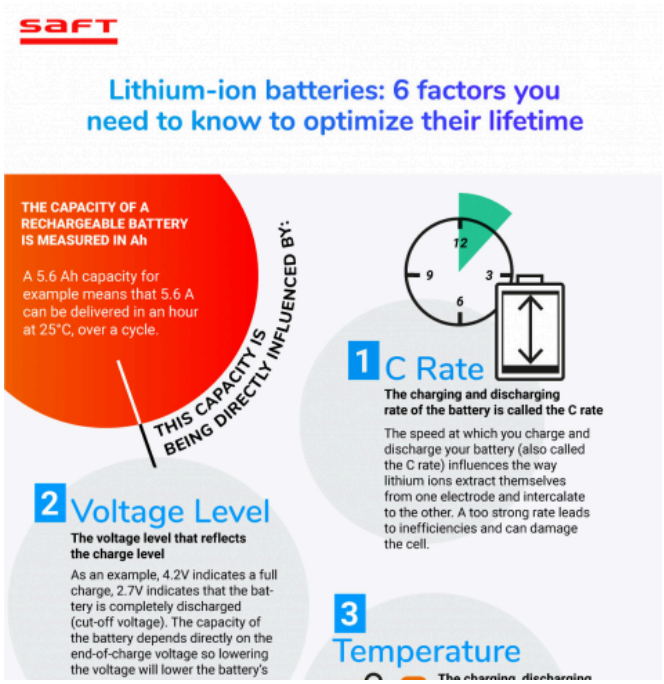
Most li-ion batteries can only withstand a maximum temperature of 60°C and are recommended to be charged at a maximum of 45°C under a C/2 charge rate, whereas **Saft's MP range can sustain a C charge rate up to 60°C and even C/5 up to +85°C for the xtd products thanks to its unique design.**

Very few batteries can be charged below 0°C. The electrode sheets contract and the electrolyte electronic conductivity gets lower which complicates the intercalation of the ions in the graphite. Lithium deposit can be generated which cause permanent capacity loss. To compensate and allow for the ion to intercalate properly, some manufacturers recommend charging the battery at very slow rate (C/20) when operating below 0°C.
Saft's MP range can handle charges at very cold temperatures —up to -30°C!— when applying C/8 and even C/5 rates.

Let's summarize our 5 top tips on how to charge your industrial-grade lithium-ion batteries to optimize their lifespan:

- **Top tip 1: Understand the battery language.** Knowing how a battery works will help you optimize the way you charge and discharge to make the most of your rechargeable battery
- **Top tip 2: Respect a CCCV charging process, especially when on floating mode (the charger is your best friend)**: Rechargeable batteries need to follow a specific charging process, usually handled by a carefully selected charger.
- **Top tip 3: Carefully design your BMS (your other best friend)**, especially when using multiple cells battery pack.
- **Top tip 4: Lower your charging C rate:** At low charging speed, the ions are intercalating themselves smoothly in the electrode, thus extending the battery's lifetime.
- **Top tip 5: Control the charging temperature:** Batteries work best when charged at ambient temperature. High or low temperatures lead to premature ageing of the battery.

See our next article offering more tips to optimize your lithium-ion battery when in operations!



For more information on **Saft MP rechargeable range**, visit the product page: https://www.saftbatteries.com/products-solutions/products/mp-small-vl

And if you'd like to read more about how our batteries operate, check out our case studies:
Fuji Tecom is preventing water leakage and offering more efficient operation thanks to an innovative water leakage detector
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