OPERATING EV BATTERIES SAFELY

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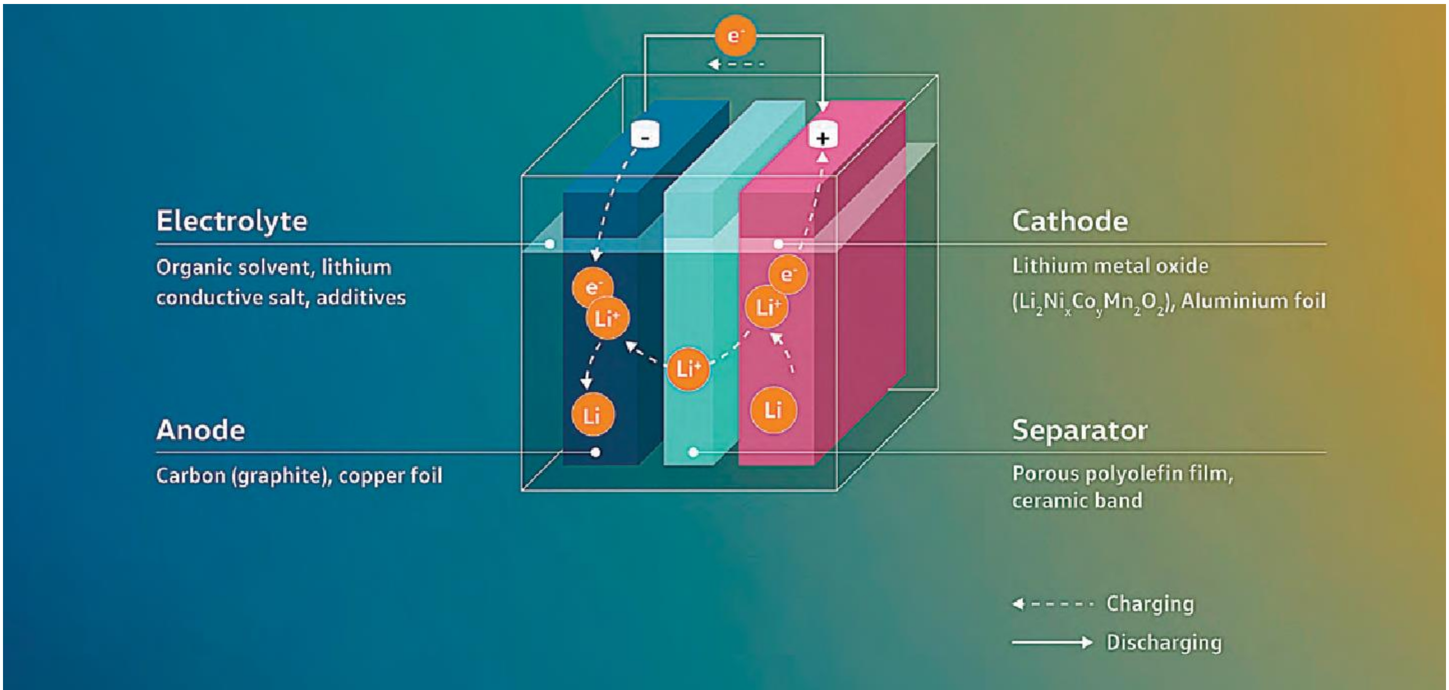


ILLUSTRATION: VOLKSWAGEN

How a li-ion battery works.

LEADERS AND PUNDITS in the automotive industry seem to agree that the automobile's transition to electrification now seems inevitable. As if to underscore this conclusion, Elon Musk has steered Tesla, the darling of EV car owners, to meeting his "rash" production targets for 2020 and with it leapfrogged to the position of the world's wealthiest person.

It is acknowledged that a critical turning point which has contributed to the acceleration of EV adoption happened when lithium-ion battery chemistry was developed by Professor John Goodenough in the 1980s. In anticipation of this transition, it appears that there are fresh announcements every day about hopeful manufacturers of new EV vehicles, their batteries and other major systems.

Whenever technology paradigms change, it is usually accompanied by a variety of experiments involving specifics of technology, process and design. Equally, new technologies are often welcomed with a level of hype that has been well chronicled in the Garner Hype Cycle analysis. In summary, for technologies at their infancy, hopes are sky-high and the challenges are opaque. Here, we unravel one of the important aspects of lithium-ion batteries — and discuss how they may be operated safely.

Multiple chemistries at work

Unlike the now familiar lead-acid battery which the auto industry has used for over a century, lithium-ion batteries employ a variety of chemistries (involving cobalt, nickel, manganese, ferrous-oxides) and designs. These elements collectively define their nature. They also depend on electronics and software algorithms (embedded in the battery management system or BMS) that carefully manage their use and which define how they are nurtured. Together, these factors significantly influence how they perform, how long they last, and how safe they are in operation.

Right: In August 2020, Grinntech announced rollout of a range of high-tech batteries with proprietary, IoT-enabled Battery Management System.

Managing the risks

One of the topics that cause the greatest amount of anxiety for developers of EV vehicles is related to battery safety. The prospect of batteries catching fire due to accidents, design flaws or improper use haunts every vehicle manufacturer whose concern for safety of customers, financial liability and brand reputation is understandable. Even a brand as robust as Tesla endured an investigation by regulators in recent years due to vehicles catching fire after its batteries were damaged. Tesla's stock price took a corresponding beating, even if it was temporary.

Battery fires, very much like other fires, involve two contributing conditions. First, there needs to be a source of ignition. Second, there must be combustible materials that allow start and propagation of fire. Each step may be caused by multiple factors. Some of the important ignition sources are discussed on the next page.

Cathode degeneration: There are many different cathode materials available under the Li-ion chemistry family, like NMC, LFP, NCA, LMO and LCO. Cathode materials can start degenerating at either high voltage (generally 4.5V and above) or high temperature (150 deg C or more). Both the voltage and temperature thresholds vary depending on chemistry, material quality and manufacturing quality. In addition to careful manufacture of cathodes, a properly designed BMS can ensure that these thresholds are not breached, thus ensuring safety.

Internal short: An internal short between anode and cathode may create an instantaneous high temperature zone which can act like an ignition source. These shorts can be created by dendrites formed on electrodes piercing the separator. Thus, a good quality separator can make a battery much safer. A short can also be created by very high current discharge or discharge at very low temperature, shrinking the separator. Thus, a good quality BMS communicating with vehicle and controlling the current draw according to battery temperature can make a safer battery.

Electrolyte disintegration: The electrolyte used in Lithium-ion cells are generally lithium salts such as $LiPF_6$ or $LiBF_4$ in organic solvents such as ethylene carbonate. They can disintegrate at high voltage and create gases like highly flammable hydrogen and carbon-monoxide. When there is any ignition source as in cases when there is foreign-object penetration or a vehicle crash, this can create a fire. Carefully chosen and good quality electrolytes with suitable additives can increase stability at high voltage, thereby making the battery much safer.

Here's looking at some of the major fire propagation mechanisms.

Thermal runaway condition: Cathode materials can go into thermal runaway conditions when operated above certain threshold temperatures, meaning they can release enough energy to sustain the continuous burning of nearby material. This situation is very dangerous and can result in complete burning of battery pack and even the vehicle. A good quality cathode material along with a BMS with proper design and protection can avoid the likelihood of this situation.

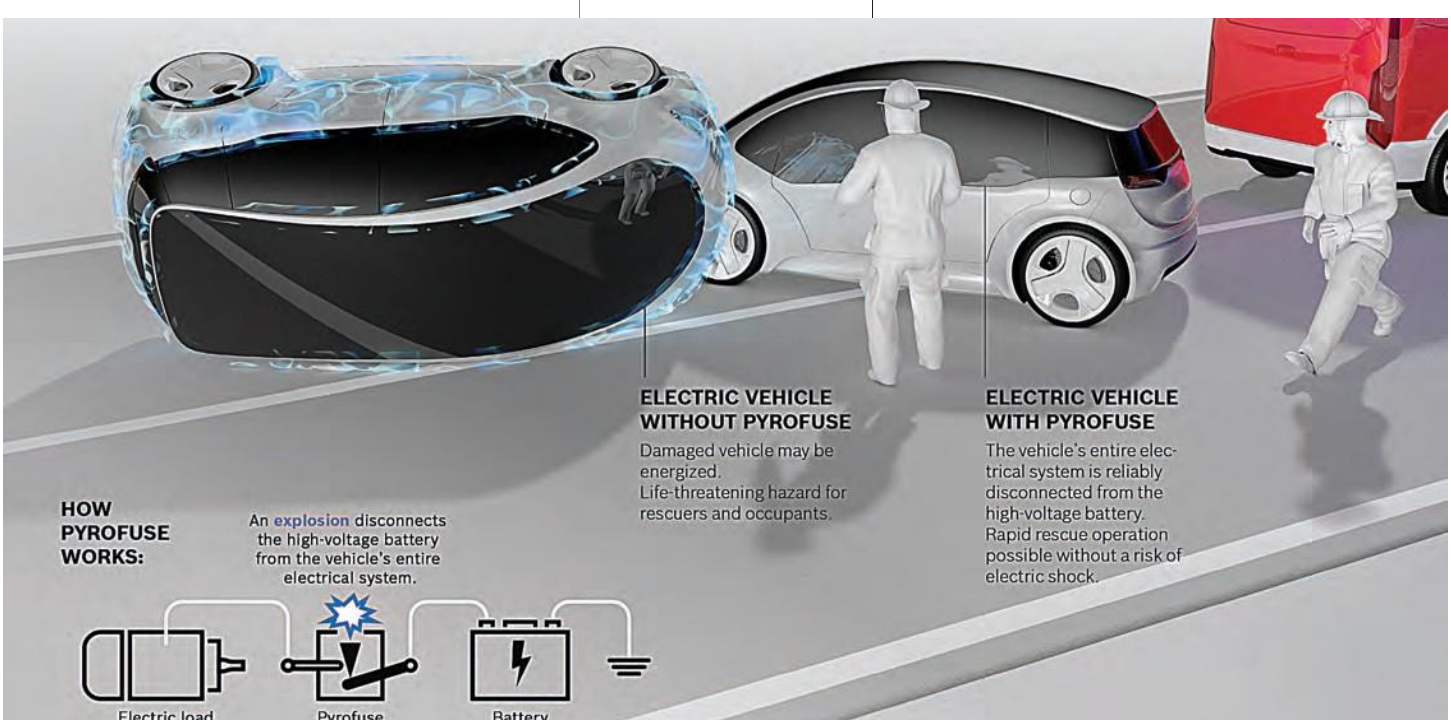
Non-validated or exaggerated claims of performance, endurance and safety can mislead EV manufacturers into wrong choices that can lead to costly consequences.

Battery packaging material: A Li-ion battery is made up of cells along with significant amount of packaging material. These materials could be plastic or metals. Components made from plastic are preferred because of their electrical resistivity, reducing chances of current leakage and an electrical short. These plastics can burn and sustain a fire if they are not of the correct fire-retardant grade. Thus, it becomes very important to use the right grade of plastics. A new fire resistance test has been added in the upcoming AIS-156 (replacing AIS-048) certification process and this will ensure safer products.

Steering a safer and sustainable course

It is important to acknowledge that the world of applications call for different priorities. Clearly a manufacturer of small, low-cost electric two-wheeler has different priorities compared to one dealing in e-vans, e-LCVs or high-performance vehicles. Hence, each application needs to be carefully tailored to its needs for performance, operating range, long life, space efficiency and cost budgets. This requires knowledge and experience in designing and integrating a safe battery system involving careful attention to each of the aspects noted namely, structural, and thermal design, BMS system, and careful selection of chemistry and materials (related to anode, cathode, electrolyte).

In summary, compared to lead-acid batteries, Li-ion batteries come in many varieties and careful design optimisation is necessary to ensure that they perform safely during their operating life. Non-validated or exaggerated claims of performance, endurance and safety can mislead EV manufacturers into wrong choices that can lead to costly consequences. Like in so many domains, an informed manufacturer will gravitate to reliable suppliers and emerge as an enduring sector leader in the coming years.



Bosch shows how to keep electric shock at bay after a crash. Pyrofuses 'blow out' whole sections of the cable connection to the high-voltage battery by means of miniature explosive charges, thus quickly and effectively shutting off the power circulation.

ILLUSTRATION: BOSCH