WHITE PAPER

Batteries Are Everywhere – So Are Their Hazards

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As battery use expands across sectors, it promises cleaner, greener energy. At the same time, it's important to recognize that batteries also come with risks. They can both cause and aggravate fires if proper preventive measures are not in place.

The Future Belongs to Batteries

Batteries, those 'chemical objects' in which chemical energy is transformed into electrical energy, have long been ubiquitous. And now, in this time of massive worldwide electrification spurred by climate change awareness, demand for them is huge and growing. Industry - especially the chemical sector - is investing massively in this new green eldorado. Many chemical companies have joined forces with carmakers: BASF with Porsche[1], Solvay with Renault and Veolia[2], TotalEnergies with Stellantis[3], LG Chem with General Motors[4] and many others. These partnerships are engaged in a global race to improve battery sustainability and performance by increasing energy density, reducing charging times, expanding battery lifespan or recycling their components, such as cobalt,

1 https://newsroom.porsche.com/en/2021/company/porsche-cellforce-basf-development-partners-lithium-ion-batteries-25194.html

2 https://en.media.renaultgroup.com/news/groupe-renault-veolia-solvay-join-forces-to-recycle-end-of-life-ev-battery-metals-in-a-closed-loop-1564-989c5.html

3 https://totalenergies.com/media/news/press-releases/groupe-psa-and-total-create-automotive-cells-company-joint-venture

4 https://www.ultiumcell.com/latest-news/2021/04/16/GM-and-LG-Energy-Solution-Investing-23-Billion-in-2nd-Ultium-Cells-Manufacturing-Plant-in-US

lithium and nickel. The stakes are high when it comes to research and development related to membrane materials, electrodes, electrolytes and battery management systems.

Among the more promising developments is the race for manufacturing solid-state batteries at an acceptable price. Japan is leading the way in this field, with more than 1/3 of the global patents[5]. Solid-state batteries are intrinsically safer and less prone to start fires, because solid electrolytes are non-flammable. Some studies show that under thermal runaway conditions, heat generation inside a solid-state battery is only ~20-30% of conventional batteries with liquid electrolytes[6].

Recognizing Battery Risks

This is of critical importance, because with the proliferation of battery use, fires caused by batteries as well as those aggravated by their presence are multiplying. It can almost seem like "another day, another battery fire" based on media coverage and Internet videos where firefighters try to extinguish battery-induced flames. Often, they ultimately decide to let the area burn and focus on preventing spread, because battery fires are notoriously intractable. Indeed no one can stop a thermal runaway once it has started. Monitoring solutions will not prevent propagation when a thermal event is underway. This is what makes battery fires so spectacular and – depending on the location of the fire - sometimes deadly, such as those that have resulted in airplane crashes.

Battery fires occur in many industrial sectors and in everyday objects: in cargo, on boats, in planes, in cell phones, laptops or electric vehicles. The American Consumer Product Safety Commission (CPSC) reported 25,000 battery fire incidents in more than 400 consumer products between 2012 and 2017[7]. Some are listed in the table below.

Application	Country	Year	Incident description
Energy	Australia	2021	Fire of Geelong 450MWh storage plant after initial testing
Automotive	USA	2021	Recall of 69000 electric vehicles due to faulty LG Chem batteries
Marine	Norway	2019	Hybrid-battery ferry on fire due to coolant leaking
Computer	Global	2019	Apple recalls a "limited number" of Mid2015 MacBook Pros because the battery may overheat and pose a fire safety risk.
Automotive	UK	2018	i-Pace suddenly on fire while parked.
Energy	Various	2017	Battery fires in large grid-connected systems
Automotive	USA	2016	Electric car suddenly on fire while parked.
Aerospace	USA	2013	Sudden failure in auxiliary units of Dreamliner 787.
Automotive	USA	2011	Chevy Volt on fire weeks after crash test.
Aerospace	South Korea	2011	Crash B744 Jeju due to cargo on fire - 2 fatalities
Aerospace	UAE	2010	Crash B747-400F Dubai due to cargo fire - 2 fatalities
Computer	Japan	2006	Sudden failure of batteries powering notebooks.
Aerospace	USA	2006	Accident DC8 Lithium-Ion Philadelphia
Cell phone	Finland	2003	Sudden failure in batteries of mobile phones.

Table 1: Some battery fire events – from Diaz & al[8]

5 https://asia.nikkei.com/Business/Business-Spotlight/Can-Japan-and-Toyota-win-the-solid-state-battery-race

6 Inoue, Takao; Mukai, Kazuhiko (2017-01-18). "Are All-Solid-State Lithium-Ion Batteries Really Safe?–Verification by Differential Scanning Calorimetry with an All-Inclusive Microcell". ACS Applied Materials & Interfaces. 9 (2): 1507–1515.

7 https://www.cpsc.gov/s3fs-public/High_Energy_Density_Batteries_Status_Report_2_12_18.pdf

8 Laura Bravo Diaz et al 2020 J. Electrochem. Soc. 167 090559

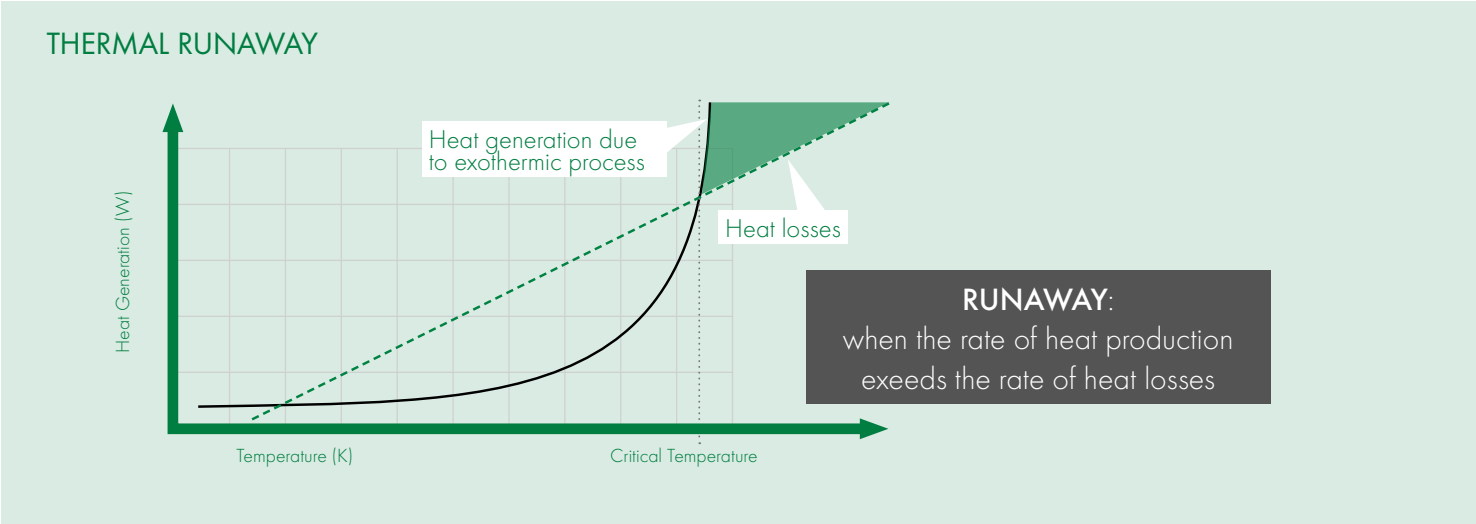

Figure 1: Battery fires once started are barely extinguishable

One of the most recent and spectacular such events happened in Australia at a large energy production park in July 2021, as shown in Figure 2.

How battery fires are triggered depends on several parameters, one being the specific technology of the battery involved. For instance, the fire risk exposure from Li-Ion batteries varies depending their use in energy storage systems versus bulk storage such as warehouses. But it is possible to classify battery fires as either the result of external causes (electrical short-circuits, mechanical or thermal abuse) or internal causes (such as defects). Both can lead to a rapid release of heat that accelerates the phenomenon, resulting in a thermal runaway, as mentioned above. The flammable and usually toxic gases that escape will eventually ignite and, depending on the immediate environment, the fire will spread.

Where Regulations Fall Short

Many national and international regulations and standards address battery safety, in particular for e-mobility, targeting manufacturing, installation, operation and maintenance, as well as battery transport. And while there are relatively few rules related to battery storage and use in industrial applications such as energy storage systems, they are being developed. Rechargeable batteries, given their versatile use, are subject to a wider and more varied series of legal frameworks, from raw materials handling, manufacturing and design, to transport, use, storage and end-of-life management. The Batteries Regulation (formerly Batteries Directive 2006/66/EC currently under revision), UN Transport Regulation, **REACH** or Waste Electronic and Electrical Equipment (WEEE) Directive 2012/19/EU are all examples.

Unfortunately, however, as demonstrated by the examples presented here and by current statistics, existing standardization and regulation have failed to satisfactorily prevent accidents. For example, following a large battery fire in December 2020 in France, the newly created BEA-RI (the French equivalent of the US Chemical Safety Board) recommended that its national authority "update the regulation to better cover design, installation and operation of electric accumulators' charging facilities." Similar developments in other countries are certain to follow.

Figure 2: Fire at Victorian Big Battery site near Geelong (Australia) on July 29, 2021. The fire broke out during testing of a battery megapack. Credit: Fire Rescue Victoria

Expert Support Services for Battery Safety

DEKRA, dedicated to making the world safer, has been deeply involved for many years in all aspects of battery safety. We offer product testing (see Figure 3) and consulting on battery design, implementation or transportation in various industrial sectors and throughout the battery's value chain, all of which dovetail with our other safety-centric services. We are available to answer any question relating to battery safety, from integrator and users alike. We provide assistance with regulatory compliance and, more importantly, help prevent the massive losses that a battery fire can cause.

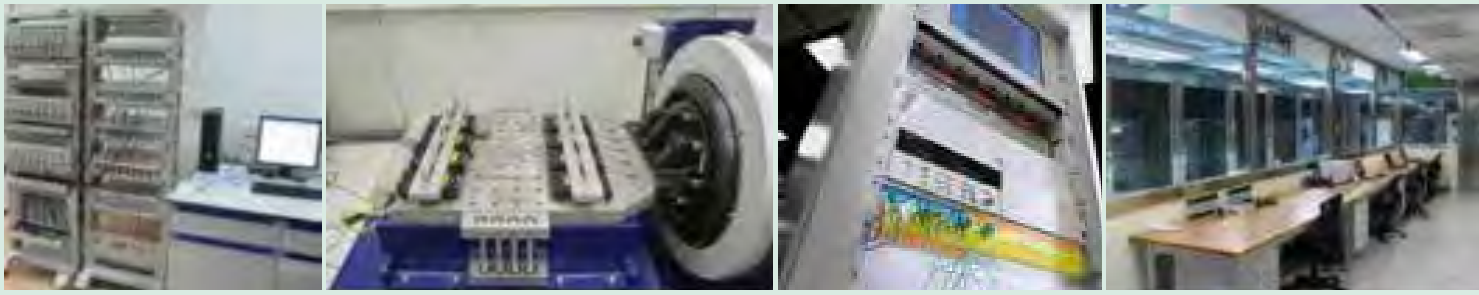

Figure 3: Some DEKRA battery testing workbenches

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Hervé Vaudrey, VP for Global Sales at DEKRA Corporate, is passionate about process safety. Having delivered over 100 process safety trainings worldwide in French, English and Spanish, he is an experienced lecturer on a wide range of process safety subjects. He draws on extensive chemical and pharmaceutical sector experience to advise and consult with leading companies in the process industries.

DEKRA Process Safety and Chemical Safety

The breadth and depth of expertise in process safety makes us globally recognised specialists and trusted advisors. We help our clients to understand and evaluate their risks, and work together to develop pragmatic solutions. Our value-adding and practical approach integrates specialist process safety management, engineering and testing. We seek to educate and grow client competence to provide sustainable performance improvement. Partnering with our clients we combine technical expertise with a passion for life preservation, harm reduction and asset protection. As a part of the world's leading expert organisation DEKRA, we are the global partner for a safe world.

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