



THE BATTERY BOOM

The explosive rise of thermal runaway
and how you can prevent it



A rise in batteries, a rise in risk

The growing danger of thermal runaway

With a rise in a more environmentally-conscious approach to energy solutions, sustainable power sources such as lithium-ion batteries have become increasingly commonplace since the 1990s, from consumer electronics to smart grids. However these batteries need storing—and such storage is not free from risk. Lithium-ion batteries are combustible and hazardous, with the potential of dangerous and explosive thermal runaway—which can not only have devastating consequences for the environment and property, but can threaten human life. With greater demand comes greater risk, and when it comes to battery storage, just one faulty battery can result in fire, explosion and damage to multiple units at huge costs.

In recent years, there have been a number of high-profile BESS insurance claims relating to the combustion of lithium-ion batteries, with insurers requiring a focus on risk reduction around fire. **But fire is a symptom, not the cause.** Identifying a problem before it results in fire is the only way forward.

As the use of lithium-ion batteries is predicted to continue to grow rapidly, it's more important than ever that we enhance safety measures surrounding their storage.

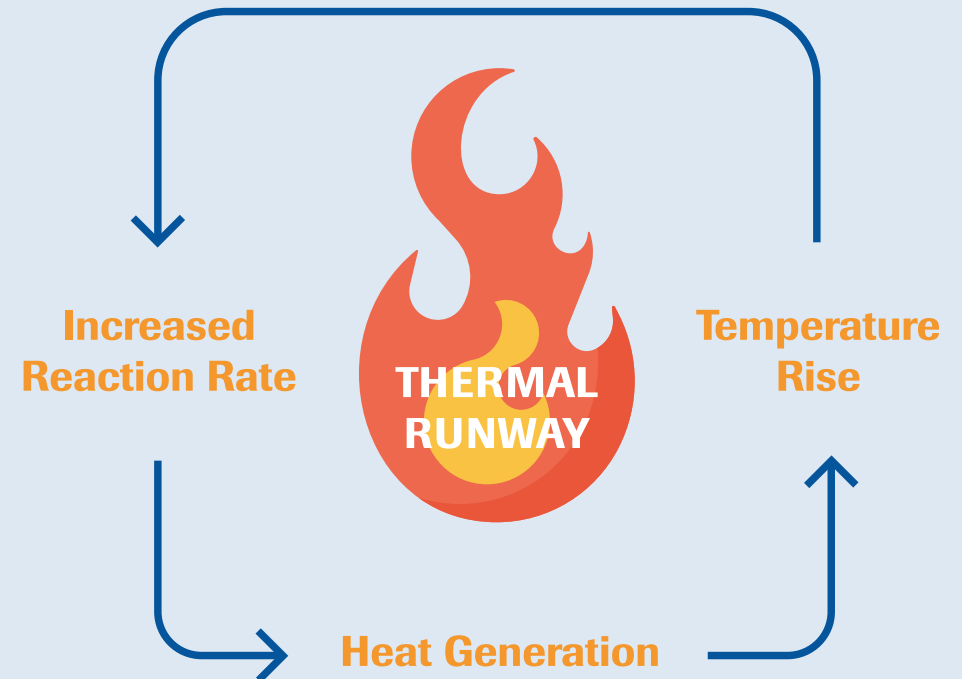
Here, we break down how to identify the early signs of danger, before thermal runaway can lead to fire, and what you can do to safeguard your people and business, before the worst can happen.

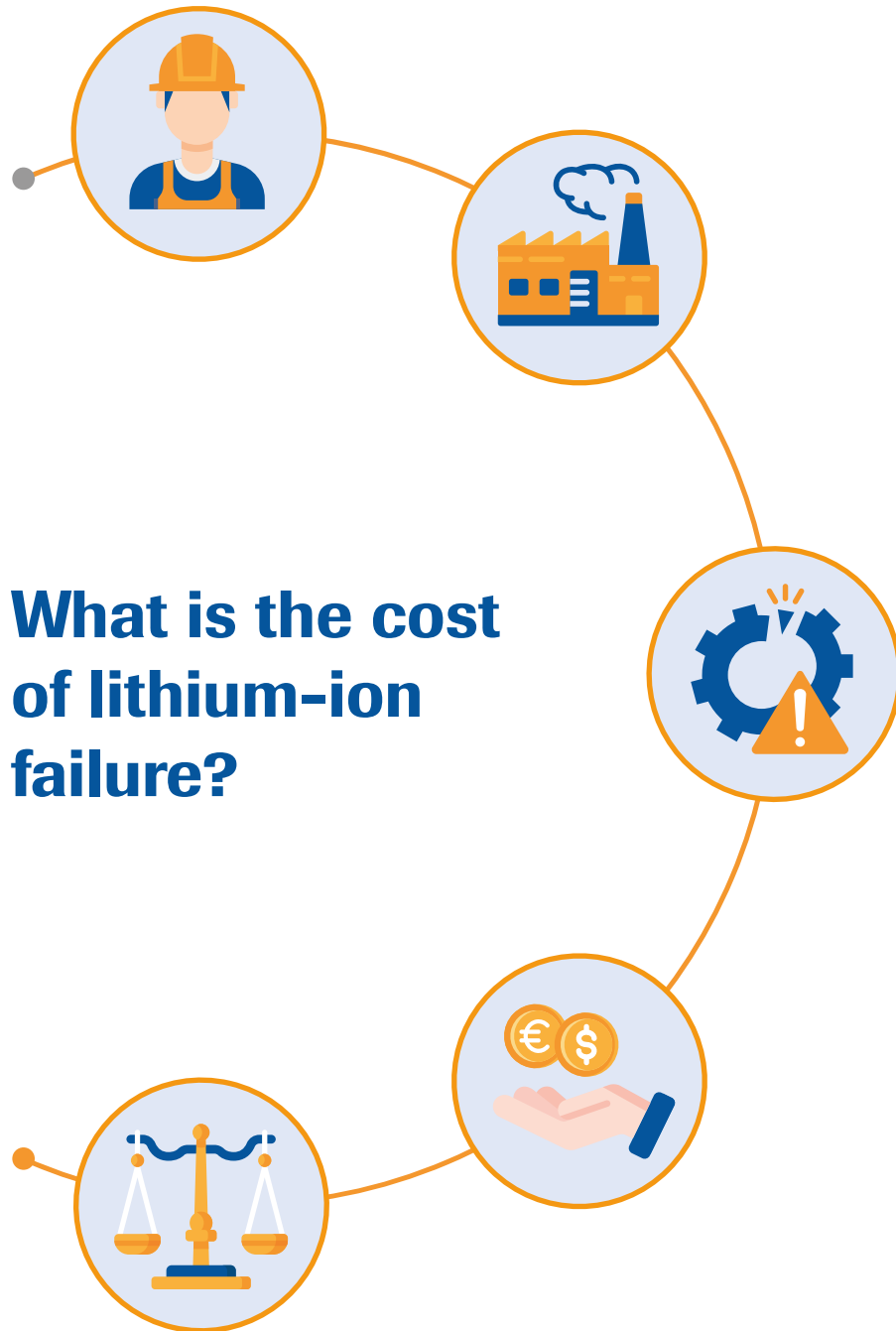
The real cost of thermal runaway

What is thermal runaway?

Thermal runaway occurs when elevated temperatures within the battery trigger exothermic reactions in the electrolyte and electrode materials, leading to further heat generation. This positive feedback loop accelerates the temperature rise, causing a rapid increase in pressure and gas production within the battery cell.

Factors such as overcharging, internal short circuits, mechanical damage, or manufacturing defects can exacerbate this process by increasing the rate of heat generation, or compromising the integrity of the battery's internal components. Batteries become uncontrollably hot, triggering this process and may result in fire or explosion—which is why identifying damaged or faulty batteries at the earliest signs is of paramount importance.





What is the cost of lithium-ion failure?

Human life

If you have seen thermal runaway, you will appreciate how deadly battery-related fires and explosions could be, due to the speed and ferocity in which they can occur. Any personnel in the vicinity would be an immediate fire-related risk, but furthermore exposure to the toxic fumes released could have unforeseen consequences to those attempting to put out the fires. The ongoing healthcare expenses of those affected could have far reaching financial implications, too.

Property damage

Thermal runaway can cause extensive damage to buildings, vehicles, equipment, and infrastructure at huge cost in an incredibly short amount of time, due to its explosive and volatile nature. However thanks to the temperature-sensitive nature of lithium-ion batteries, the presence of fire can mean all batteries in the vicinity could also propagate thermal runaway, exacerbating the damage incurred.

Business disruption

The disruption to your business following fire can be devastating with production delays, supply chain disruptions, and revenue losses. These costs are then compounded by other potential financial penalties, loss of market share, and critically damage customer relationships.

Financial costs of extensive cleanup operations

Removing hazardous materials, decontaminating affected areas, and restoring environmental quality following battery failure are laborious and expensive processes, but environmental remediation costs can be extensive, too. Contamination of soil, water, and air pollution from released chemicals or hazardous materials can damage ecosystems and cause public health risk, potentially leading to fines or penalties, and require long-term investment in monitoring and maintenance efforts.

Legal and reputational costs

Battery failures can result in legal liabilities, lawsuits, and regulatory fines, particularly if negligence or misconduct is alleged. Legal expenses can include litigation costs, settlement payments, and damages awarded to affected parties. Furthermore, reputational damage can be a lengthy and expensive PR process that can take years to re-establish trust.

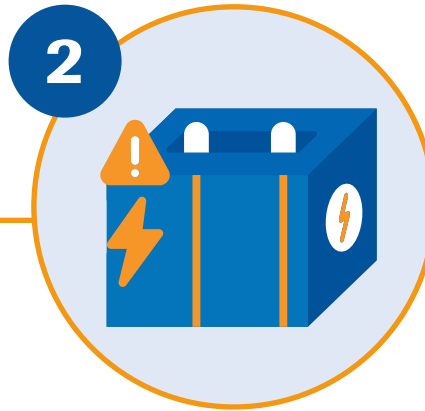
How do battery failures start?

There are three kinds of battery failure:



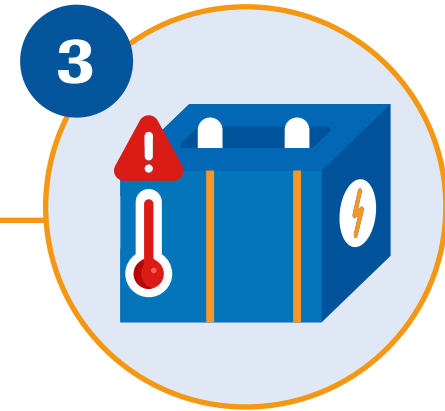
Mechanical Failure

This occurs when the physical structure of the battery is compromised, leading to short circuits or damage to internal components. It can be caused either by physical damage and puncture or manufacturing defects, which can lead to electrical contact between different battery components, triggering thermal runaway.



Electrical Failure

Malfunctions within the battery's electrical system, such as internal short circuits or overcharging, can lead to the rapid release of stored energy, causing overheating and potentially initiating thermal runaway. Electrical failure may result from manufacturing defects, improper usage, or ageing of the battery.



Thermal Failure

Thermal failure occurs when the battery's temperature rises uncontrollably due to internal or external factors, leading to thermal runaway. Factors such as overcharging, high ambient temperatures, or poor thermal management can cause excessive heat buildup, triggering chemical reactions that further elevate temperatures and potentially result in fire or explosion. Thermal failure is a critical concern in lithium-ion batteries due to their sensitivity to temperature changes and the potential for catastrophic consequences.

Any one of these failures could result in a fire- **even when they aren't charging**. Once a battery catches fire, their sensitivity to temperature means all other batteries in proximity are at risk- a particular issue when it comes to storage. You may lose multiple containers or buildings as a result of just **one** faulty battery.

Learning from high-profile incidents

There have already been numerous high-profile instances of lithium-ion batteries causing extensive damage, with far-reaching implications for the local areas:



The question is, how can you prevent something like this happening to your business?

Off-gassing: The first sign of possible disaster

'Off-gassing' refers to the release of gases from lithium-ion batteries under certain conditions, such as overheating or thermal runaway. These gases can include volatile organic compounds (VOCs), carbon dioxide, carbon monoxide, and other potentially harmful substances- which can be toxic for any firefighters who may come in contact with them. Although not always a guaranteed precursor to thermal runaway in lithium-ion batteries, off-gassing events typically occur early in their failure. Early detection, therefore, means faulty batteries can be identified and isolated before catastrophic thermal runaway begins.

Monitor, safeguard, prevent

In some cases, off-gassing may occur as a result of the battery attempting to relieve pressure buildup during the early stages of thermal runaway.

However, it's important to note that off-gassing alone does not always indicate imminent thermal runaway. Rather, it is one of several potential warning signs that the battery may be experiencing stress or operating outside of normal parameters. Monitoring off-gassing along with other factors such as temperature, voltage, and current can help in detecting and preventing thermal runaway events in lithium-ion batteries, and enable you to identify a faulty or distressed battery before thermal runaway can start.

To put it simply: being able to identify the presence of those gases can be one of the best safeguards your business has in preventing the catastrophic damage which thermal runaway can cause.



The risks of off-gassing build-up & the need for gas detection

Should off-gassing go undetected, the risks go beyond thermal runaway. A buildup of gases in a battery storage container can turn the container into a pressure vessel, which could need just one spark to explosively ignite—which is why insurance underwriters place emphasis on keeping LFL and LEL low.

Underwriter Laboratories' standard for energy storage systems and equipment (UL9540) states that BESS needs to maintain lower than 25% LFL or have a container that can open to vent gas, to prevent the build-up of flammable gases like hydrogen.

The market often focus on fire safety requirements* that specify the use of safety equipment such as fire & smoke detectors, thermal sensors for temperature, and fire suppression systems to handle fires once they start. However **it's much more important to prevent fires to begin with.**

Are you compliant with your insurance policy?

Some insurers property loss prevention policies state emergency exhaust ventilation must be activated “if hydrogen is detected at 10% LEL”** - which means gas detection is essential. **Because if you can't detect it, how can you know?**

* See UL9540

**FM Global (Insurance company of the certification body FM), has a document (FMDS0533) on BESS Property Loss Prevention which states the emergency exhaust ventilation system should be activated “if hydrogen is detected at 10% LEL”.

Thermal Runaway

In the event of thermal runaway, off-gassing can occur rapidly and in large quantities as the battery reaches elevated temperatures and undergoes violent chemical reactions.

Normal Operation

During regular use, lithium-ion batteries may undergo a small amount of off-gassing as a result of chemical reactions within the battery cells, which is normal and minimal.



Overcharging or Overheating

Overcharging, high temperatures, or other abusive conditions can cause the electrolyte in the battery to decompose, leading to the release of gases and increasing risk of thermal runaway.

Charging and Discharging

Off-gassing may increase slightly during charging and discharging cycles, particularly if the battery is subjected to high rates of charge or discharge.

Key takeaway: Monitoring off-gassing levels and addressing any abnormal conditions promptly is essential for maintaining battery safety and preventing potential hazards.

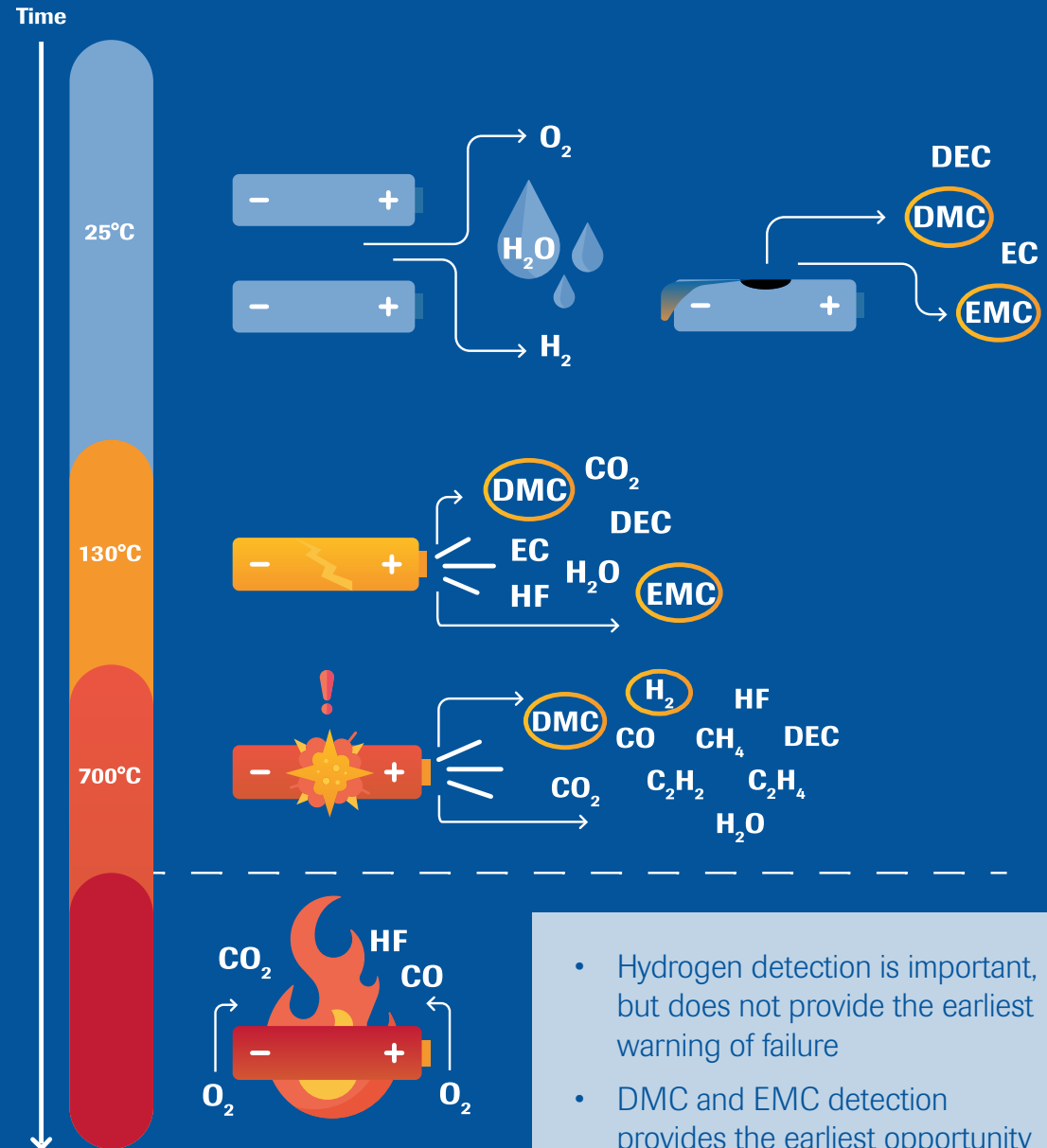
Beyond reactive: proactive strategies for containing thermal runaway

The early detection of off-gases is pivotal to containing thermal runaway. Investing in protection and detection is a minor expenditure when compared to the costs of a thermal runaway fire or explosion, which can potentially result in almost immeasurable loss. Put simply, **can you afford to do nothing?**

Early detection, elevated protection

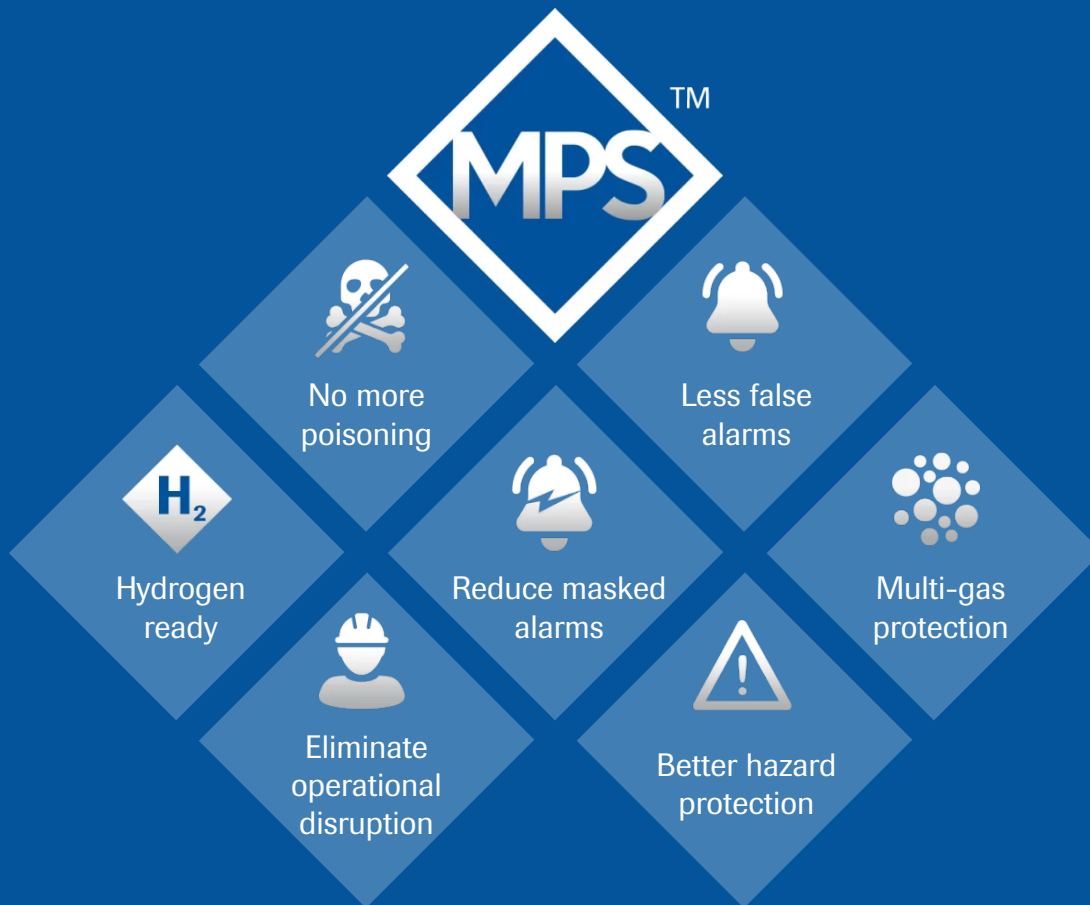
Crowcon's solution empowers users with early off-gassing detection, providing a critical advantage by alerting them before a battery reaches the dangerous precipice of thermal runaway.

Flammable liquids are used as electrolytes in the production of batteries. Carbonates, such as dimethyl carbonate (DMC), ethyl methyl carbonate (EMC), or diethyl carbonate (DEC), are required to keep the electrolyte viscosity low and the electrolyte conductivity high. DMC = Dimethyl Carbonate (Flashpoint: 17-18°C), EMC = Ethyl Methyl Carbonate (Flashpoint: 23.9°C)



The MPS™ Sensor Detects DMC, EMC, H₂ and Hydrocarbons

- Hydrogen detection is important, but does not provide the earliest warning of failure
- DMC and EMC detection provides the earliest opportunity to warn of battery failure



Introducing the Molecular Property Spectrometer™ (MPS™) sensor

We've created a technology that surpasses traditional gas sensor methods in reliability detects and identifies over 15 different flammable gases automatically in real time.

About MPS™ Technology

- DMC and EMC detection provides the earliest opportunity to warn of battery failure
- The MPS™ resists contamination and prevents sensor poisoning.
- Only one MPS™ device is needed, helping to save space without compromising on safety.
- It doesn't require constant calibration, reducing interaction with the detector resulting in a lower total cost of ownership over the sensor life cycle.
- Scheduled maintenance is no longer needed through self-monitoring and auto-reporting functions.

A cleaner, brighter energy outlook

The shift towards more sustainable energy solutions and away from fossil fuels is undoubtedly helping pave the way for a brighter future for all. But with the increased demand for batteries to provide renewable energy, comes an increase in battery incidents involving fires and explosions connected to thermal runaway.

Without early detection, one faulty battery has the potential to cause untold damage to property and even human life, with costs that could result in irreparable harm to a businesses finance and reputation.

With effective gas monitoring, early signs of thermal runaway can be detected and prevent the worst from happening, helping to safeguard your business for a tiny percentage of the cost attached to doing nothing.

With the growing demand for lithium-ion batteries in an eco-conscious world, vigilance, stringent safety protocols, and robust emergency response plans are imperative to mitigate these risks effectively. It's a problem the team at Crowcon are ready to solve.

Book a call with a member of our team to find out more about how to use early gas detection to safeguard your business' future.





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