First Responder Safety

Gas detection considerations for incidents involving vehicles with alternative drive systems

Dräger

Technology for Life

Major growth in alternative drives

Since 2013, battery-electric and plug-in hybrid electric vehicles have experienced strong growth, especially in China, Europe and the United States.

The global electric car stock will reach

100 million vehicles

by 2026

Source: Bloomberg Electric Vehicle Outlook 2023

New challenges for first responders

In the event of an incident, alternatively powered vehicles can exhibit a wide range of behaviours. Irrespective of the powertrain, one of the main challenges is the potential release of flammable or toxic gases, vapours and liquids. This can happen if the integrity of the tank is compromised and fuel or gas leaks, or if a battery electric vehicle experiences a thermal runaway.

This can result in:

- Exposure to toxic substances for personnel or casualties without PPE
- Risk of jet flames and deflagration
- Increased risk of explosion where gases and vapours can accumulate in poorly ventilated areas (e.g. tunnels, garages)

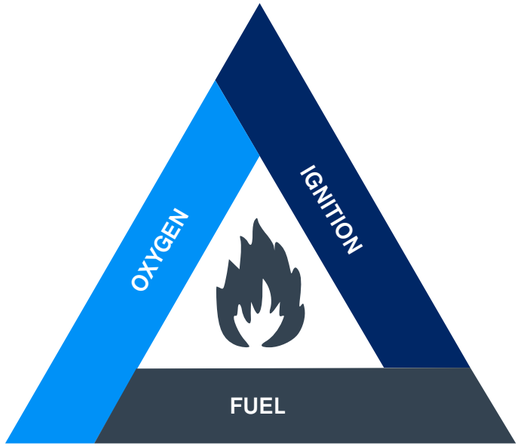
Thermal runaway

Battery-cell thermal runaway refers to the overheating of the cell due to a self-reinforcing heat generation process. This process can be triggered by a cell failure. This includes mechanical damage, penetration, overcharge, short circuit and internal defects. Thermal runaway often results in fire or explosion. During incidents, clouds of toxic and flammable gases and vapours are released from the cells. These flammable vapour clouds can sometimes be mistaken for smoke or steam. In order to keep first responders safe the risk of deflagration or explosion needs to be detected.

Fire triangle

The fire triangle components are present within the battery:

- Oxygen (present in the cathode materials)
- Combustible substances (electrolyte, separator, anode material)
- Heat (external or internal to the battery)



Factors influencing Thermal Runaway, among others:

- State of Charge (SOC)
- State of Health (SOH)
- Active Cathode Material (LFP, LNMO, NMC)

Off gassing

The gasses that are released from batteries during thermal runaway are highly flammable and toxic.

Produced gases depend on cell chemistry

- Cathode materials (NMC, LFP, ...)
- Anode materials (often graphite)
- Electrolyte including carbonates (DMC, DEC, EMC)

Different volumes of toxic and flammable gases may occur

- Carbon Monoxide, Hydrofluoric Acid and other toxic gases
- Hydrogen
- Methane, and heavier combustible and toxic hydrocarbons

Recognising and averting the danger

Catalytic sensors used by first responders measure how the surface of flammable substances react in order to calculate the concentration of present gases or vapours. Using this method, the sensors have different degrees of sensitivity towards different substances depending on the type of gas measured.

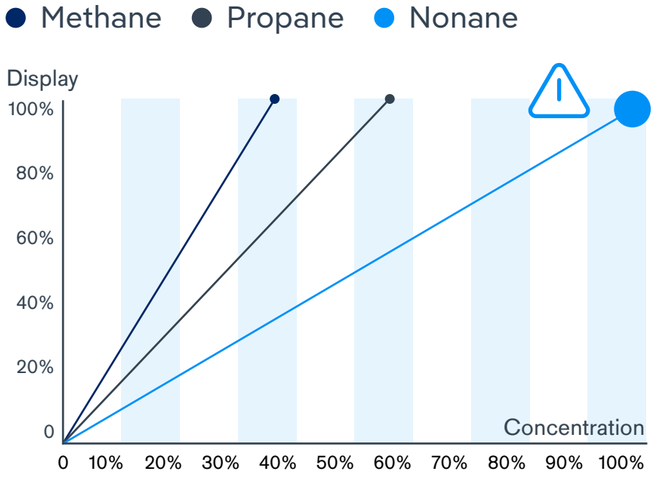
Detection challenges

The detection method poses two challenges:

Which gas is expected?

To select the measurement gas, it is important to know which gases and vapors can occur. For example, if exposure to hexane or nonane is possible, the detector must be calibrated for this substance due to its low level of sensitivity.

How the measuring gas influences a catalytic sensor's sensitivity to different gases



A catalytic sensor will react more sensitively to methane compared to nonane as shown in the graph. As a result, a sensor calibrated for methane will be less sensitive to nonane and likely to underestimate the threat, whereas a sensor calibrated for nonane will be highly sensitive to methane and overestimate the threat.

Wear and tear

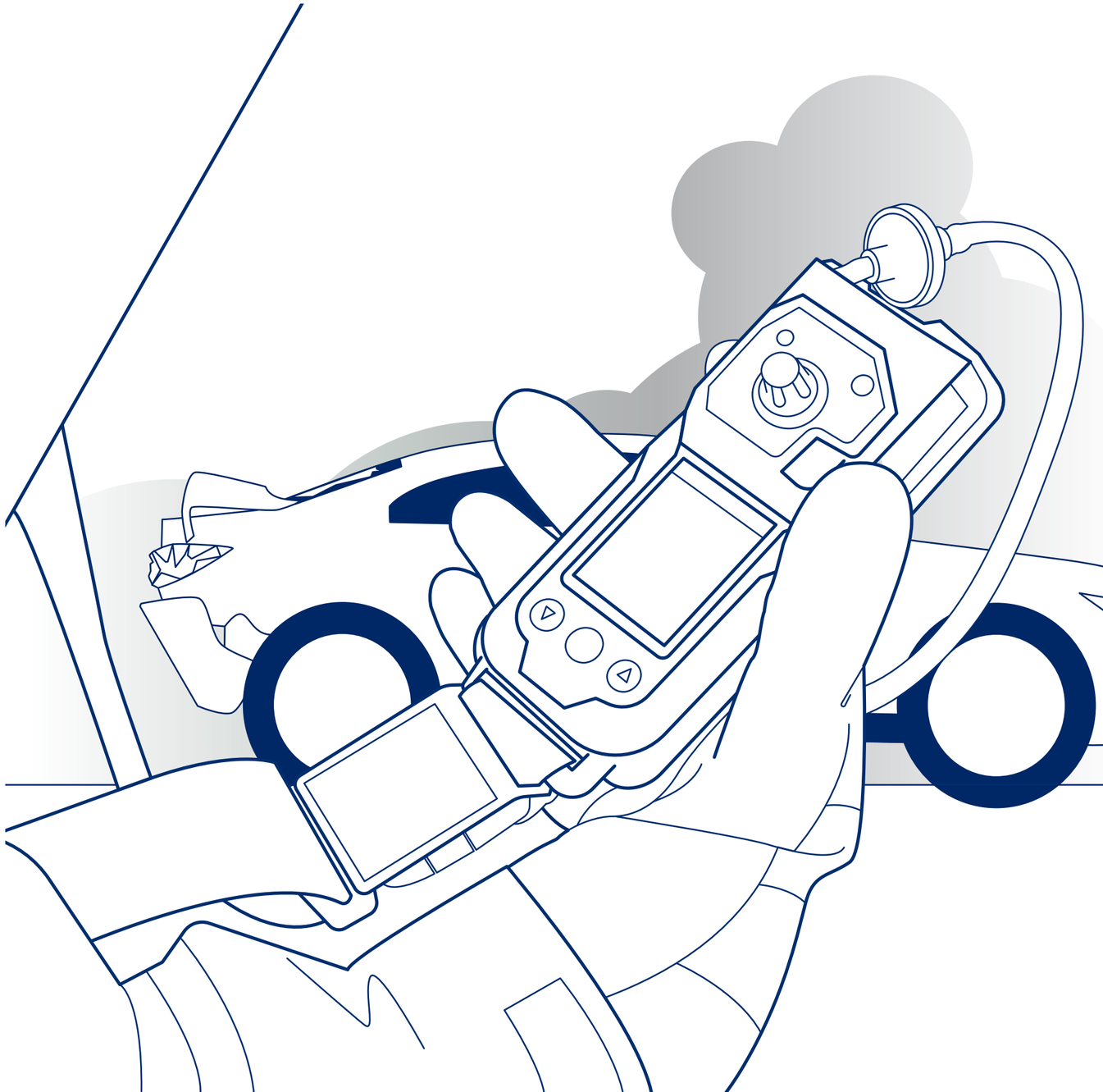
Regular testing of sensors for methane sensitivity is needed to ensure accuracy and safety, as the sensors may age or become contaminated, reducing the level of sensitivity specifically to methane.

Measurement recommendations

The European standard EN 60079-29-2 (Selection, installation, use and maintenance of detectors for flammable gases and oxygen) and the German industrial standard (DIN) 14555-12 contain several recommendations for gas detection, in particular DIN 14555-12 (Vehicles carrying tools and gear – Part 12: Hazardous material (HAZMAT) vehicle GW-G) can be considered as an example for gas detection in the fire service.

These recommendations include:

- When uncertainty exists about the mixture of expected gases the detector should be adjusted to the substance with the lowest sensitivity
- The capability of the detector to detect Nonane
- If Methane may be expected, it must be used as the test gas to be able to determine methane insensitivity



Two incident scenarios

In an incident involving an alternative drive vehicle there are 2 possible scenarios:

Scenario 1 – without flames

In the event of an incident involving an alternatively powered vehicle, the release of toxic and flammable emissions must be considered to ensure the safety of first responders.

The following table gives an **overview of the properties, hazards and detection strategies for alternative drivetrains.**

- Flammable gas or vapours
- Toxic
- Lighter than air
- Heavier than air
- Lighter or heavier than air

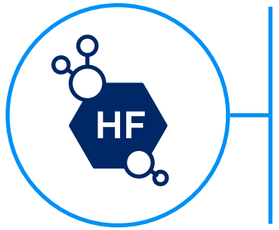
Drivetrain	BEV/PHEV	H2	CNG	LPG
Symbol according to ISO 17840-4				
Properties of leaks or off-gasing	Visible white vapour and dark smoke, aromatic odour Loud hissing and popping sounds indicate a thermal runway	Non-odourised, colourless	Odourised, colourless	Liquid evaporates faster than petrol, odourised
Hazards				
Released substances	Mixture of various substances, e.g. Hydrogen, Methane, various heavier hydrocarbons, CO, NO_2, SO_2, HCL, HCN, HF, and various VOCs	Hydrogen	Methane	Butane and Propane
Special considerations	Flammable and toxic vapour cloud may be mistaken for steam	Hydrogen flames may be invisible to the eye, H2 is not detectable by IR-Ex sensors		
Simple detection strategy*	Multigas detector with Cat-Ex sensor calibrated for n-Nonane to detect all combustible mixtures, O_2, CO			
Advanced detection strategy*	X-am 8000** with Cat-Ex sensor with selectable measurement gas to adapt quickly to the specific scenario			
	Methane Butane Additional sensors for O_2/CO, NO_2, HCN and VOCs X-am 5100 HF/ HCL, Dräger Tubes	Methane Additional sensors XXS H_2 HC for the specific measurement of H_2	Methane	Butane

* The selected substances have been chosen based on current knowledge to cover the most basic needs of firefighters to be able to make an initial assessment of imminent threats posed by flammable and toxic gases. BEVs in particular may release a multitude of varying substances based on cell type, chemistry and state of charge. ** Firmware 01.04.12 or higher

Scenario 2 – visible flames

In the event of an accident involving a fire, emergency personnel must take special protective precautions due to the inherent hazards of a burning vehicle.

Toxic and irritant emissions from burning fuel, plastic, and rubber (e.g. CO, HF, HCl, HCN, SO2, NO2, and PAHs)



Elevated levels of **hydrogen fluoride and metal particles and ions have been observed** for burning battery-electric vehicles

It is essential to always use **SCBA and full PPE** due to these emissions

Substances can accumulate on firefighters' protective gear and skin, making **proper post-incident** hygiene critical

Personnel not using SCBA need to maintain a safe distance from the vehicle in order to not be exposed to hazardous emissions. A gas detector can help to determine this parameter.

Detection solutions

Dräger has a selection of solutions which protect the health and safety of firefighters and first responders.

Gas detection to detect the release of flammable and toxic substances

X-am® 2800 and 5800

X-am® 8000

X-am® 5100

Gas detection tubes

Thermal imaging camera to detect invisible flames by H2 and detect and monitor a thermal runaway

Dräger UCF® Firevista

Dräger UCF® FireCore

Personal protective equipment

Dräger has a selection of solutions which, when combined, protect the health and safety of firefighters and first responders.

PPE (Personal Protective Equipment) to protect first responders and victims

Dräger HPS® SafeGuard

Dräger PSS® AirBoss

Dräger PARAT® 5500***

Dräger RPS® 3500 and rescue hood

*** Filter solution – may not provide protection from all released substances

Summary

Hazards for first responders in Incidents with alternative drivetrains

New Hazards are facing first responders especially related to batteries – domestic, industrial, mobility

- High energy
- Be aware of the vapour cloud
- Fire vs. explosion

Knowledge is key

- Be aware of the risks in your area of responsibility
- Know your tools
- Train and adapt to stay safe