

FOR A SAFER ENVIRONMENT OF ELECTRIC AND HYBRID VEHICLES



Photo: Andreas Sutter, Biel Switzerland

Dafo Vehicle

is introducing a safer environment for electric and hybrid vehicles

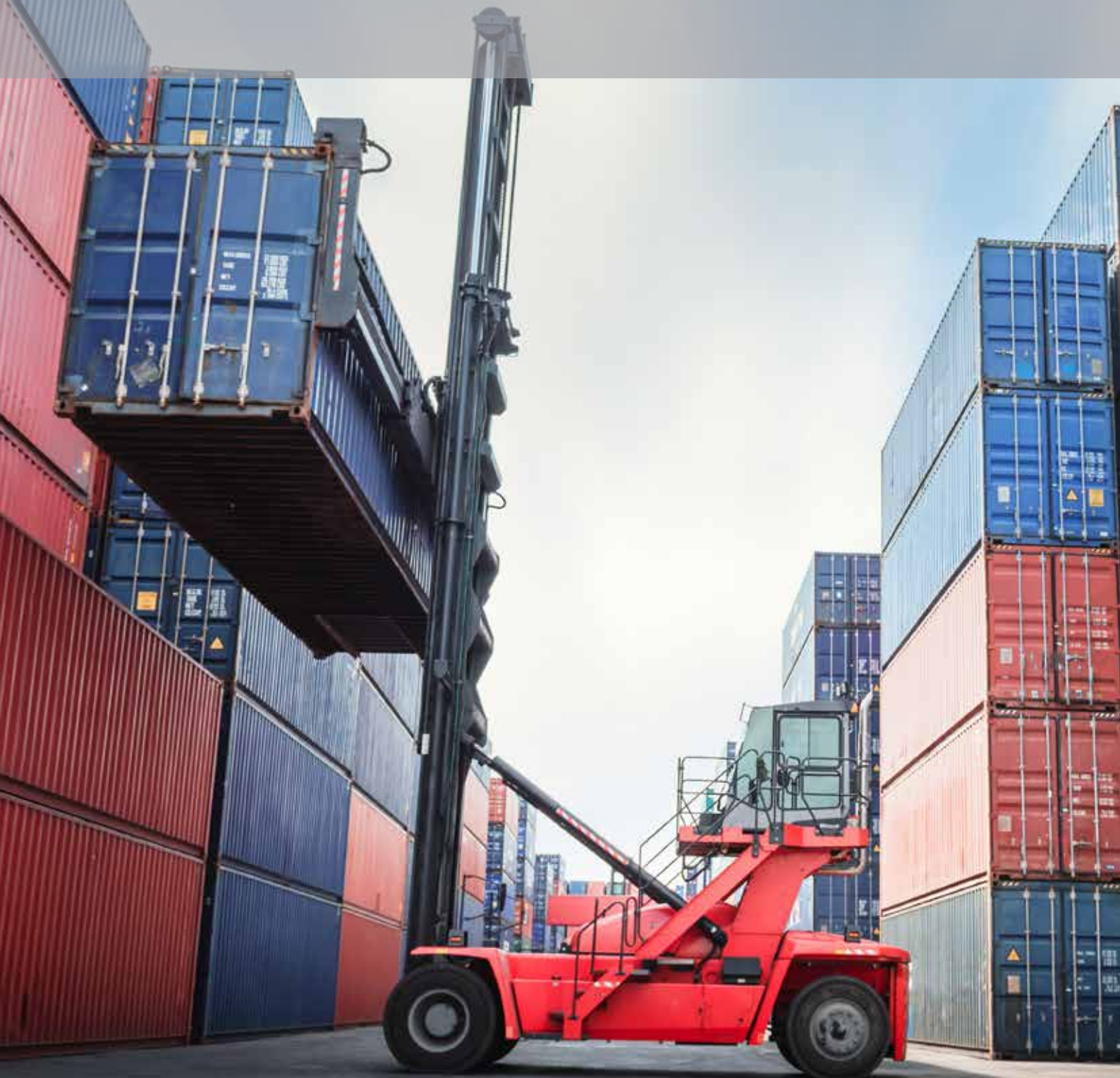
There is a global transition to renewable fuels and by that an increasing demand for electric and hybrid vehicles (EV and HEV). As more electric vehicles become operational, their involvement in fire incidents is likely to rise.

The significant fire risks associated with vehicles being powered by batteries and high-power electric engines/devices are not widely understood. For example, the consequence from a malfunctioning Li-ion battery can be very serious, potentially resulting in a thermal runaway situation with rapid fire and heat propagation as well as emission of toxic gasses, posing a great threat to vehicle drivers, occupants as well as the environment in which the vehicle is operating.

From a regulatory standpoint, fire risks in electric and hybrid vehicles are currently being treated as similar to those in traditional combustion engine vehicles. For example, this stance is taken by GRAMKO, the health and safety committee of the Swedish industry organization for mines, mineral and metal producers, stating that fire standards need to be kept/further enhanced when transforming from diesel engines to electrical powertrains.

You could argue that fire risks are actually increasing when introducing electrical vehicles. As an example, a significant part of the fire risks in a traditional combustion engine vehicle is related to the electrical system of the vehicle. These types of risks are further accentuated in an electric vehicle, having more electrical components, more wiring as well as higher power running through the electrical system. In addition, the Li-ion battery adds a whole new risk element to an electric vehicle.

Through multiple international collaborative research projects in which studies were made of fire risks associated with lithium-ion batteries in vehicles, Dafo Vehicle Fire Protection has developed the Li-IonFire™ fire protection system that addresses and mitigates these risks effectively and safely.



Differences in risks and additional risks between diesel-powered vehicles and EV and HEV

The difference between diesel-powered vehicles and EV and HEV from a fire risk perspective is related to the location as well as the character of the potential fire sources. In vehicles with combustion engines, the location of most fire sources is concentrated in the area of the engine compartment. In EV and HEV vehicles potential fire sources

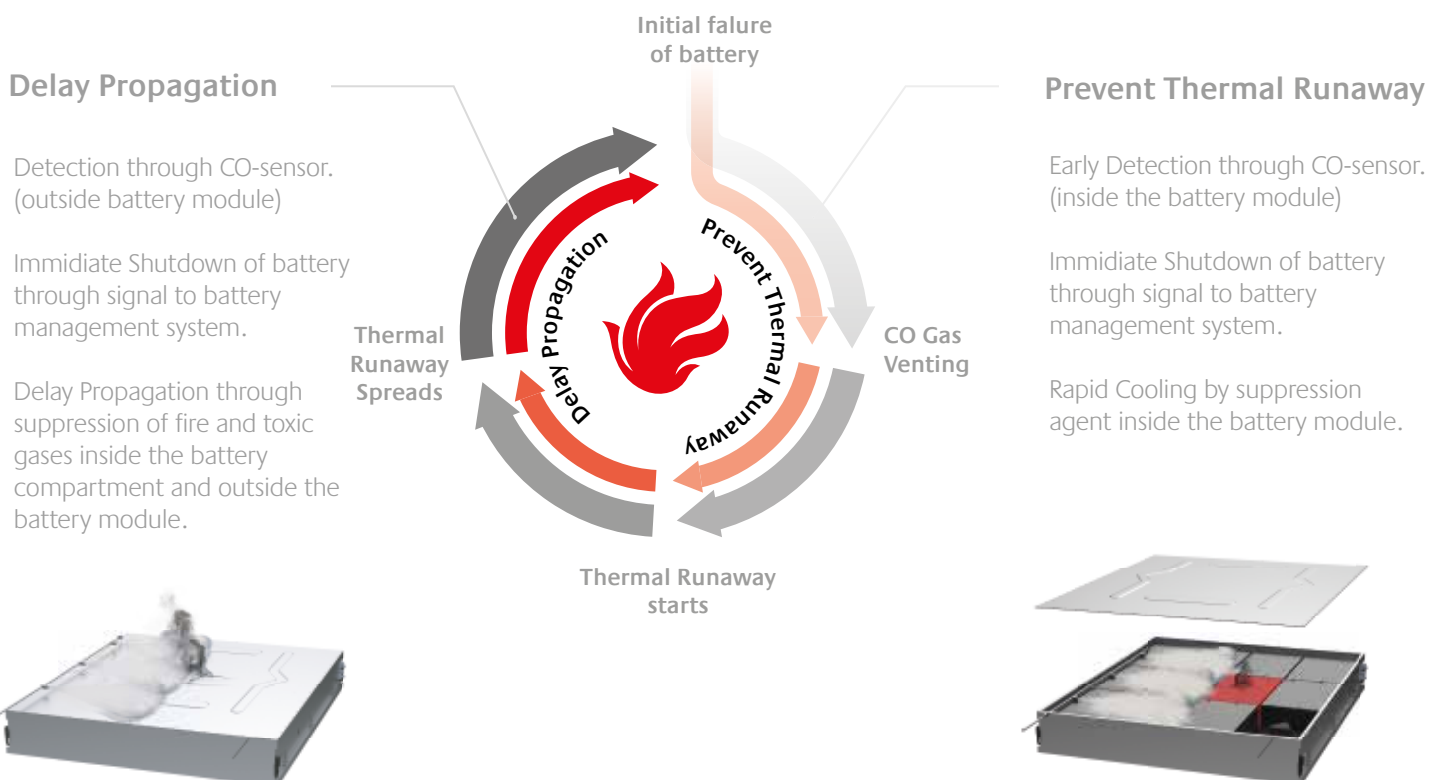
are often located in different sections of the vehicle. It means that more protection zones will have to be taken into account. Furthermore, a combination of different extinguishing methods will have to be used due to the different types of fires that might occur, as well as the sensitivity of electrical components.

Challenging risks related to Li-ion batteries

When Li-ion batteries fail through short circuiting, overcharging, high temperatures, mechanical damage and overheating, this might cause thermal runaway. Thermal runaway occurs when a battery cell has reached the temperature at which the temperature will continue to increase on its own and the electrolyte catches fire. Through this it becomes self-sustaining as it creates oxygen which feeds the fire. As the heat

source and the fuel are both existing within the battery these fires can develop quickly. The release of flammable electrolyte makes fire extinguishing very difficult and in addition there are a lot of toxic gases being emitted such as hydrogen fluoride, which can cause serious damage to both the skin and the respiratory tract.

Stages of Li-Ion Battery Failure & Dafo Vehicle Solution levels



Dafo Vehicle has developed a full coverage multi-zone fire protection solution in response to the urgent need for risk mitigation in EV and HEV vehicles. The suppression agent Forrex EV™ is used as one part of the complex system solution and it provides effective cooling capacity to slow the fire development for allowing safe evacuation of machine operators. In order to cover all

risk areas in the EV or HEV vehicle, the main risk scenarios are typically divided into four protection zones.

The different protection zones are then protected in various ways by robust detection and suppression systems – both liquid based and gas-based solutions.



Zone 1 Engine compartment

Protection applied for combustion engine (HEVs) and compartment with electrical components (EVs) based on Dafo Vehicle's well proven liquid based fire suppression system.

- Liquid based FORREX agent.
- Robust detection/suppression technology.
- Prevents re-ignition.

Zone 2 Electrical hazards

Electric systems are a common failure source on conventional vehicles that now increases in risk with the addition of high voltage, high power traction systems.

- Detection using heat or smoke detection or combination of both.
- Clean extinguishment without any residuals through our PFK system with agent gas FK-5-1-12.

Zone 3 Traditional hazards

Many of the traditional hazards such as flammable liquids, hydraulic fluid, diesel oil, greases, lubricating oil, heaters, AC units and combustible debris still exist and has to be taken into a potential fire hazard.

- General system feature.
- Liquid based Forrex agent.
- Robust detection.

Zone 4 Batteries

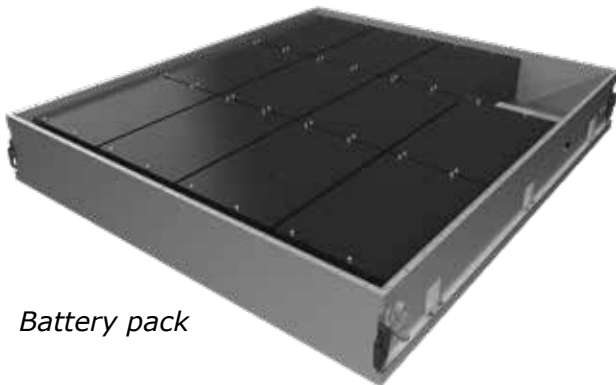
Dafo Vehicle's liquid based fire suppression system is used to protect battery pack from external fires as well as to provide maximum cooling in case of a thermal runaway battery fire in order to create sufficient time for evacuation of machine operators.

- High sensitive gas detection for early warning.
- Robust Dafo Vehicle linear detection.
- Double amount of liquid compared to normal combustion engine application is used.

Li-IonFire™ concept

As a solution to specific risks related to batteries Dafo Vehicle has developed the Li-IonFire™ fire protection system. The system will detect potential battery failure, at the earliest possible stage and take immediate action by cooling, using the suppression agent Forrex EV™. This will effectively stop, or delay, a potentially hazardous situation without the fire developing further.

Depending on the protection level that needs to be achieved the Li-IonFire™ solution can either be applied outside the battery packs or as an integrated part of the packs. Li-IonFire™ solution can also be limited to detection only without the suppression application.



Battery pack



*High-sensitivity
CO sensor*

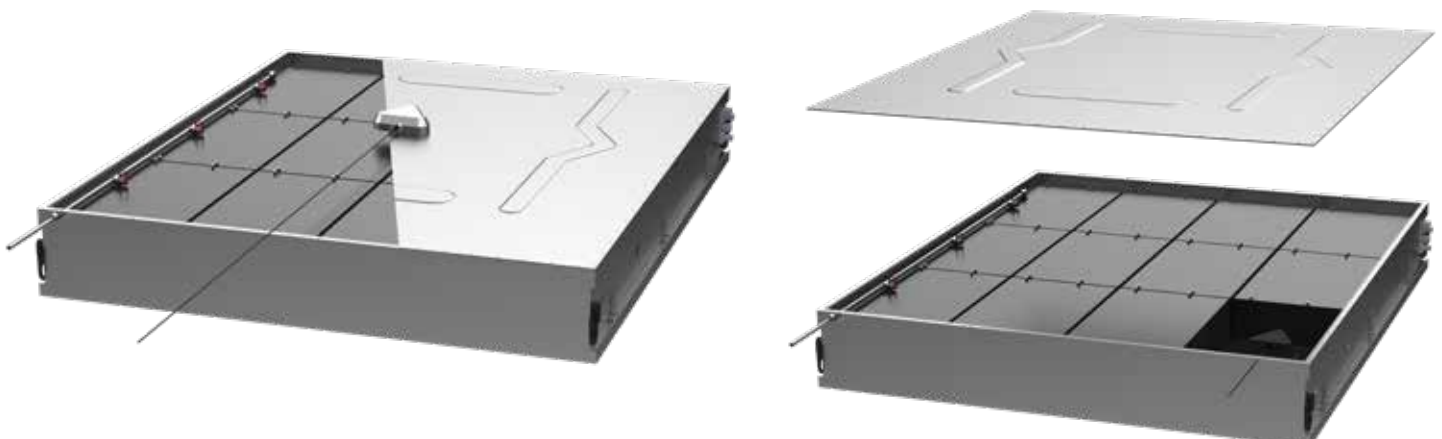
Distributed detection and suppression thanks to full bi-directional CANbus communication. The extinguishing agent is only deployed at the detected risk area.

Easy to customize to the customer-specific needs and type of vehicle.

Possibility to set multiple alarm and suppression criterias.



*CO sensor application
together with cooling agent
distribution system*



Examples of integrated applications

State-of-the-art graphical user interface.



Touch Screen



Informative



Alerting



Optional Features



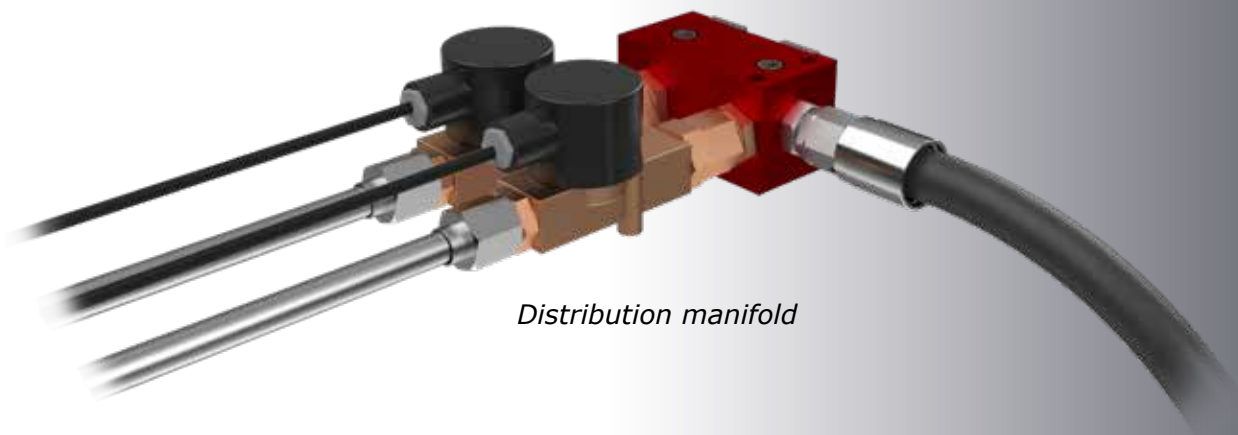
Internal Data logger



The battery pack should be cut-off upon detection and discharge of the system.

Other extinguishing agents such as powder, gas and aerosols are unsuitable due to the lack of cooling effect. Furthermore,

non-aqueous agents like powder could in some cases make a fire scenario worse by encapsulating the hazard and shielding it from further firefighting actions.



Distribution manifold

Li-IonFire™ will dramatically boost the safety of operators having heavy-duty machines in hazardous environments and the actual machine operators by allowing safe evacuation as well as boosting the protection of valuable assets. The new solution is

designed to mitigate losses due to fire and reduce the impact on investment, reducing downtime, securing business continuity as well as increasing the productivity of the end users.



Case study

Heavy vehicles

In the automotive industry, electric and hybrid vehicles are a new standard. The technology is recognized and already used in the Mining, Container Handling, Construction, and Forestry sectors. All vehicle manufacturers are aware of the ecological footprint of their products. They focus on sustainability and set goals to reach zero-emission.

Dafo Vehicle is a key part of this transition participating in several electric and hybrid vehicle projects together with leading heavy-vehicle manufacturers. Their main requirement is that the electric vehicles shall be equipped with an Automatic Detection and Fire Suppression System to further enhance the safety of operation.

The main objective for heavy vehicles in the Mining, Container Handling, Construction, and Forestry sector is to address the traditional risks such as the engine compartment in hybrid vehicles as well as electrical and hydraulic system compartments. In addition, the Li-IonFire battery needs to be protect from external heat. This means everything around the battery pack that could cause it to become overheated, for example, the electrical engine, high-voltage cables, converters, diesel heaters, and hydraulics. In future cases also the battery itself will be protected.

Further on through the system's minimized maintenance needs contribute to a high vehicle uptime and a low total cost of ownership (TCO) which is essential for the profitability of operators.

Dafo Vehicle is committed to minimizing the ecological footprint. By designing the systems and utilize technologies that minimize the need for spare parts, maintenance, and unforeseen service calls this can be realized.



Safe with Dafo Vehicle



Active fire protection is an integral part of systematic and effective fire prevention. Together with Dafo Vehicle Fire, you'll always get the most effective solution so that you can limit fire damage, reduce downtime and increase productivity.

Since the start back in 1919, Dafo Vehicle has developed into a modern, high-tech company committed to offer the very best solutions to our customers.

Dafo Vehicle has three main business areas:

Integration (Fire suppression systems integration into OEM production line, Retrofit (Fire suppression systems installed at final customer) as well as Service & Maintenance.

The Dafo Vehicle group today consist of several subsidiaries and Dafo dealers – Dafo Vehicle Fire Protection Finland OY, Dafo US, Dafo Vehicle Estonia, Dafo Deutschland, Dafo France, Dafo Russia, Dafo Asia, Dafo Spain, Dafo Australia, Dafo UK & Ireland, Dafo Brasil, Dafo Middle East & Dafo Chile.

Do not compromise safety – contact Dafo Vehicle Fire Protection already now!

