euralarm

Guidance on

Fire Safety for Parking Garages with Electrical Vehicles

Revision table

Date	Rev #	Paragraph / Page	Change
December 2024	1.0	Document	First release

FOREWORD

This Guidance Note is intended as a general guidance and is not a substitute for detailed advice in specific circumstances. Although great care has been taken in the compilation and preparation of this publication to ensure accuracy, Euralarm cannot in any circumstances accept responsibility for errors, omissions or advice given or for any losses arising from reliance upon information contained in this publication.

DISCLAIMER

This document is intended solely for guidance of Euralarm members, and, where applicable, their members, on the state of affairs concerning its subject. Whilst every effort has been made to ensure its accuracy, readers should not rely upon its completeness or correctness, nor rely on it as legal interpretation. Euralarm will not be liable for the provision of any incorrect or incomplete information.

Note: The English version of this document SC-EXT-147 is the approved Euralarm reference document.

Copyright Euralarm

Euralarm • Gubelstrasse 11 • CH-6300 Zug • Switzerland

E: secretariat@euralarm.org
W: www.euralarm.org

euralarm

Table of contents

1. Introduction

The rise of electric vehicles (EVs) has brought both environmental benefits and new safety challenges.

In this document we are referring to electrical vehicle types as plug in hybrid electrical vehicles (PHEV), and battery electric vehicles (BEV) which shall hereafter be generalized as EVs, however where risk arises from a hydrocarbon fuel then the reader must duly consider such.

EVs present unique risks such as the thermal runaway propagation within their traction batteries.

The nature of EV construction is to protect the battery cells from weather, surface water spray, and damage in normal use, and this presents a challenge in delivering extinguishant to the cells. Therefore, it is extremely challenging, if not impossible, to stop in-cell thermal runaway inside the traction battery. or slowing cell to cell propagation.

The increase size of modern cars - to those of the 1970s, including internal combustion engine (ICE) vehicles and modern EVs - is well documented, however the size of most car parking spaces has not retrospectively been changed. The resulting increased proximity and reduction in space between cars, speeds car-to-car fire propagation which is exacerbated by the significantly higher plastic content of modern cars. Increased parking density, such as car stackers and the probable emergence of autonomous parking, compounds this further still. Even with new construction, allowing for larger cars, there has been car-to-car spread evidenced.

This guidance discusses the statistics, research on fire behaviours and safety measures associated with both electric and combustion vehicles, providing an overview for safety professionals, and policymakers.

2. Scope

The scope of the document is to provide factual information on the fire risk of electrical vehicles in parking facilities in comparison with other types of vehicles and to guide through solutions that can be applied.

This paper focuses on electric (EV) and conventional (ICE) vehicles. Where parking garages also offer storage of micro-mobility, e.g. e-bikes and e-scooters, such as for security or employee/resident convenience, the increased risk of this must not be ignored. Where such is also provided with charging facilities, the risk and need for protection increase and the content of this guidance should be applied with scale.

3. Fire Risks and Loads of Electric Vehicles

According to a report from the National Fire Protection Association (NFPA), vehicle fires accounted for 15% of the 1.4 million fires that took place in the US in 2020, and those fires contributed to 18% of civilian deaths and 11% of the civilian injuries.

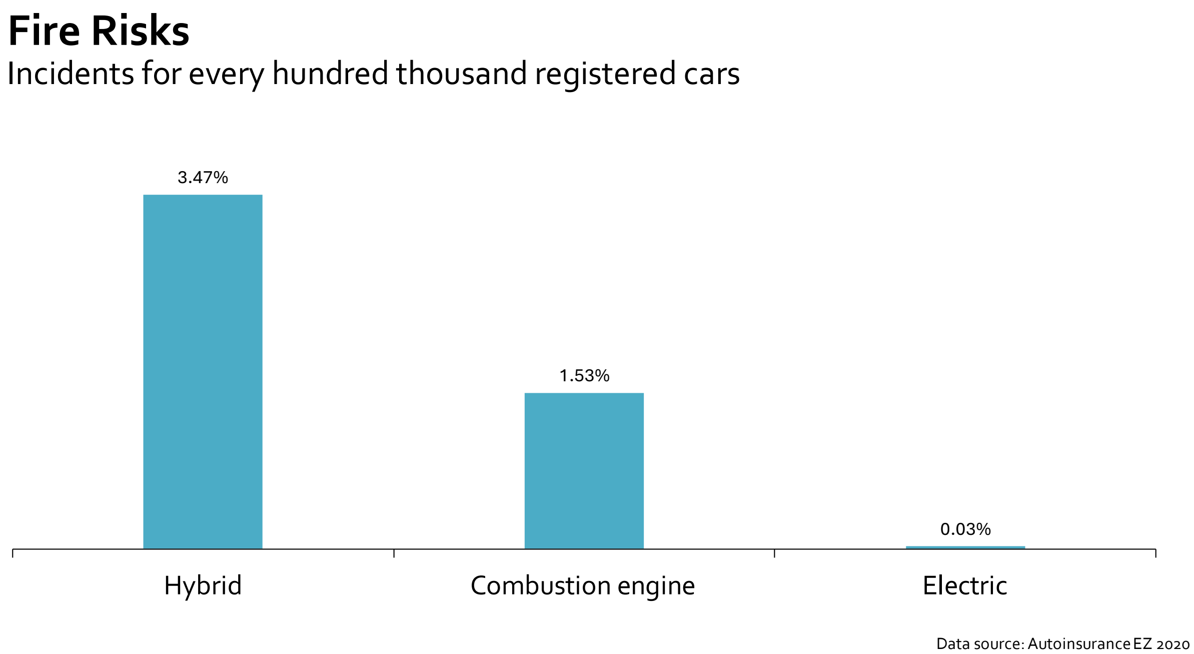
The share of EV fires was about 0.02% of the US fire total, indicating that EV fires are relatively rare compared to those in combustion-engine vehicles. It should be noted that this reality is not perceived by the public, because EVs are portrayed as more fire-hazardous as often sensationalized on social media.

However, statistical data shows that the rate at which BEVs catch fire today is orders of magnitude lower than that of ICE vehicles and PHEVs. According to AutoinsuranceEZ2020[1], for everyone hundred thousand registered vehicles there are 3470 fires for hybrids (3.74%), 1530 fires for ICE vehicles (1.53%) and less than 30 fires for BEVs (0.03%).

According to the Swedish Civil Contingencies Agency, there were 106 fires involving all personal electric driven mobility in 2022, with most occurring in e-scooters, and about 24.4% involving electric cars. This number remained stable despite a significant increase in the number of registered BEV in recent years. By the end of 2022, Sweden had approximately 215,000 BEVs registered. This results in roughly 12 fires per 100,000 registered BEVs in Sweden (0.01%).

Other countries have data available, the above being provided as considered typically indicative.

Evaluation of why PHEV are greatest risk is not available. Possible causes include the comparatively complex technology and aging. Aging of BEV and the increasing power of quick charging stations play a role that is not reflected in current statistics, which are based only on relatively new cars as it is a recent technology.



Hybrid cars take higher rates than combustion or pure electric.

Despite the differences in fire initiation, the overall fire load between electric and combustion vehicles is comparable, as a calculation by Dekra from 2022 also makes visible. Fire loads are quite similar but in electrical cars fire can last for much longer.

[1] https://www.autoinsuranceez.com/gas-vs-electric-car-fires/

Fire loads for comparable vehicle sizes

1.2t total weight

Material	Quantity	MJ/kg/kWh	Combustion Car (MJ)	Electric vehicle (MJ)
Plastics	300 kg	30	9000 (75.4%)	9000 (75.5%)
Tires	40 kg	28	1120 (9.4%)	1120 (9.4%)
Gasoline	50 l	32	1600 (13.4%)	-
Engine & gearbox oil	6 l	35	210 (1.8%)	-
LIB traction battery	50 kWh	36	-	1800 (15.1%)
			11930	11920

Data source: DEKRA Automobil GmbH 2022

Regardless of the type of car, plastic contents and tyres account for approximately 85% of the fire load of the vehicle.

The reason for the high fire load - fuel to the fire - is the ever-increasing quantities of plastics used in modern cars over the years. Even in EVs with larger batteries, the plastic content of the vehicle still dominates.

Modern garage fires also appear to be much harder to extinguish, the data revealed. In 1997, 95% of garage fires analysed were extinguished in under 60 minutes. However, in French garage fires occurring between 2010 and 2014, only 40% were extinguished in under an hour; 30% of the fires took more than two hours to extinguish, and 10% took more than four hours. By contrast, fewer than 1% the 1997 fires took longer than two hours to put out[2].

4. Differences in Fire Behaviour of Electric Vehicles and Conventional Vehicles

The manner in which fires start and propagate in EVs differs significantly from ICE vehicles as soon as the EV's traction battery is involved. Combustion vehicles store their fuel in tanks, making them susceptible to spill fires. In contrast, BEVs cannot 'spill', but rely on lithium-ion batteries, which can overheat or become damaged, potentially causing a fire. A critical concern for EVs is a thermal runaway (TR) event, where one overheating battery cell triggers a chain reaction, leading to a fire that is challenging to extinguish, as the battery module is not easily reached by extinguishing agents. Even if the propagation of TR could be stopped, there is a risk of TR restarting due to remaining "stranded" energy in the damaged battery pack.

Parking garages pose specific fire hazards for all types of vehicles, but the risks for EVs can be more severe due to the confined space and the potential for flammable and toxic gases to build up from a TR event.

The specific characteristics of an EV fire require adapting the protection strategies commonly accepted and adopted for ICE vehicles:

- Unlike ICE vehicles, which are always passive in a garage, PHEVs and BEVs can be plugged in for charging triggering active chemical and electrical phenomena, even though the engine is switched off
- The batteries of an EV can produce flaring phenomena which contributes to a more rapid spread of the fire to adjacent vehicles
- A battery fire produces toxic gases, in addition to those produced by the materials making up the vehicle common to a combustion-powered vehicle (seats, etc.)
- A battery fire can reignite after days

However, some studies have shown that the fire behavior of EVs does not necessarily lead to a faster spread of fire and that EVs do not necessarily burn faster than ICE vehicles[3].

In Germany, parking and charging EV with a certified charging system does not conflict with the applicable rules for garages built in accordance with building regulations (MBO). In France, charging stations have to be physically

[2] https://www.nfpa.org/news-blogs-and-articles/nfpa-journal/2019/03/01/protecting-parking-garages
[3] https://lashfire.eu/media/2022/09/2022-08_Facts_and_Myths.pdf

separated from other areas in public parking. In other countries different requirements can prevail.

In some eyes, charging an EV thus introduces potential fire risks, such as overheating from faulty equipment or damaged batteries and using improper or damaged charging cables[4].

According to VDI guideline 2166, type-approved EV can be parked in both private and public garages, and the charging process does not alter the original use of the space. This highlights the importance of adhering to established guidelines and ensuring that charging stations are installed in compliance with safety standards, and duly inspected and maintained.

Fire risk at charging stations

Statistics show that BEVs today have the lowest probability of fire of all car drive type. The increased probability of fire incident arises during the charging. The chargers themselves are also to be seen as safe, however the cable connection at these points poses an increased risk, especially if customers use their own, possibly poorly maintained, cables and especially at connection points. According to the Institute for Loss Prevention and Damage Research (IFS, Institut für Schadenverhütung und Schadenforschung der öffentlichen Versicherer e.V. in German language),[5] for almost 15 years around a third of fires of any kind have been caused by electrical faults or cable fires. These fires often occur in the private sector, as there is no mandatory regular inspection of electrical appliances as in the commercial sector. The causes of cable fires are varied and range from cable breakage to loose plugs and terminal connections to ageing processes (oxidation and corrosion).

This alone is certainly reason enough to take a closer look at the issue of fire protection at charging stations inside buildings. However, what needs to be considered in any case is the fact that charging stations are not reserved for BEVs. PHEV are also charged at such stations. And PHEVs are evidently, with current statistics, the vehicle class with by far the highest probability of catching fire of all drive types. PHEV introduces additional risk due to the presence of fuels and oil that may spill in the charging area. This fact makes charging stations the greatest concern when it comes to the topic of fire protection.

5. Fire Safety Objectives for Public Parking Garages in Europe. A Holistic Approach

The fire protection challenges in all indoor and underground car parks are mainly:

- Prioritize the evacuation of people and therefore save lives
- Limit the development of heat to preserve the integrity of structures
- Limit the number of vehicles involved or damaged
- Allow safe intervention by fire brigades
- Allow rapid resumption of normal activity

These goals are more complex to achieve in the case of EV since:

- The risk of fire is increased by charging vehicles, due to the charging process itself, cables used, etc.
- Burning EVs release of explosive fumes and gases
- Fumes released from EV fires are toxic
- Cars can burn for longer, once the batteries become involved due to their chemistry and the reignition hazards arising from fire damage and "stranded" energy

Without special protection or with a strategy modelled on that of legacy vehicles (i.e. smaller cars with a lower fire load), the protection concept is outdated, and the result is to very quickly exceed the threshold of preserving the mechanical strength of the structure and the risk-free intervention of firefighters. There is a body of evidence that that beyond 3 to 5 vehicles on fire, intervention becomes impossible in an indoor or underground parking lot[6].

In addition, it is not possible to quickly extinguish a Li-ion battery fire. The measures to be implemented must therefore take into account a processing time for the incident which will not be counted in hours but possibly days. Measures must be sized to remain viable throughout this time, to cover a possible reignition.

Even if there is no technical solution that can fully extinguish an EV fire quickly and automatically, there are

---

[4] Source: VDI Guideline 2166 Planning of electrical installations in buildings Advice for electric mobility, Part 2, Chap. 6.4.9

[5] https://www.schadenprisma.de/archiv/artikel/elektrische-brandursachen-im-wandel-der-zeit/

[6] Source: https://players.brightcove.net/1640544031001/default_default/index.html?videoId=6161601923001

solutions to mitigate impact of fire incidents. They should be applied to address the increase of charging points in garages.

Elements of a holistic approach are:

- Architectural measures (escape routes, positioning of charging stations, collision protection, management of nuisance to the environment being caused by combustion products escaping from and enclosed/indoor car park, management of run-off, etc.)
- Passive protection measures (separation of risks by walls, protection of ceilings by flocking, reinforced concrete floor, etc.)
- Advanced management of charging station capable of cutting power to all the chargers
- Control measures to mitigate the outbreak or intensity of fire, e.g. avoidance of combustible materials storage, etc.
- Early fire detection and alarm
- Automatic fire fighting systems
- Smoke exhaust ventilation
- Involve fire brigade to pre-establish intervention strategies, case by case
- Installed equipment available to fire-fighters, such as risers or hose reels
- Following a pre-defined procedure, removal of an EV to an outside area, after a fire has been extinguished to address the potential of reignition
- Regular maintenance of all the implemented systems

Chapter 6 presents the various levers that can be considered or combined to achieve the desired level of protection.

Depending on the context, the protection concept and the architecture of the building, the fire protection strategy can be global over the entire parking area, localized to certain areas welcoming EVs, limited to charging areas only, etc. It is the purpose of chapter 7 to present different water-based technologies like sprinkler, deluge or water mist systems.

The fire detection technology must be chosen consistent with the suppression technology and overall protection strategy. For example, early detection can be in the overarching fire strategy and then protection limited to those areas presenting the greatest risk, such as where charging occurs, making it possible to quickly act from the first vehicle catching fire to mitigate the likelihood of spread. If detection is designed to locate the fire precisely, this can also provide firefighters with valuable information for faster and safer intervention.

6. Elements to be Considered as Part of a Holistic Fire Protection Strategy

Fundamentally 'success' must be the control of the heat output - be this EV and/or ICE vehicles - to prevent car-to-car spread which has historically often led to structural damage resulting in the building collapse or the need for demolition.

Indisputably wetting and cooling needs to be applied to any fire, and as soon as possible. When this is automatic, one can presume operation whilst only the first car is involved. There is evidence that fire growth tends towards exponential once a second car becomes involved in the fire, so early intervention is crucial.

Exploring how to limit heat transfer, some approaches to be considered shall now be discussed. The focus is on heat transfer by convection and radiation, however ICE vehicles should also be considered by the reader, e.g. the prevalence of plastic fuel tanks can now result in an earlier liquid fuel spill which, if ignited, will rapidly spread fire from car-to-car.

6.1. Architectural and Organizational Measures

Physical separation can be used to limit heat transfer, subject to the parking layout. Additional walls may be more effective but can then concentrate the heat within the walled boundary, perhaps increasing the speed of ignition of other cars within that walled segment. For this reason, additional walls may calculate as less effective than increasing parking bay widths.

Localized requirement can also include:

- Charging may be limited to ground level or close proximity thereof
- Requirements for ramps and access ways to facilitate the easy removal of EVs - where access is normally via an elevator, a post-fire alternative is necessary – or even mandate charging stations are/are not proximate to entrances/exits and/or even only allowed on specific floors
- Hydrants/risers (dry or wet) may be required, and/or fixed hoses
- Fire and Rescue Service (FRS) access to electrical distribution controls must not be affected by a fire at a charging location
- Charging which relies on the EV owner’s cable being prohibited and the charger must have its own fixed cable or different rules specifically for rapid chargers

6.2. Charging Station Installation Measures

If risks increase when charging EVs, rather than just parked, and the likelihood of TR increases with state of charge (percentage charged), then a reliable battery management system (BMS) is paramount. Voltage and current irregularities can indicate an unfolding incident; cessation of charging alone might prevent a fire at that time.

The need for substantial power for charging, and other reasons, often concentrate charging stations in one area as well as proximate to buildings.

If the objective is to prevent car-to-car fire spread then containment with architectural measures, heat and smoke removal, detection, and automatic control / suppression, etc must be considered in addition to what legislation and local regulation mandates for basic life safety.

This naturally includes position of charging apparatus to prevent accidental damage, such as from collision.

An emergency manual power kill switch, affecting all charging stations, may be required possibly with vandalism resistance.

6.3. Automatic Detection

As exampled at the Luton and Stavanger airport fires, caused by ICE cars, automatic detection would likely have resulted in different outcomes. The delay from first human discovery of the fires to the FRS emergency call was unnecessarily and avoidably retarded. Had the FRS notification happened sooner, then they may have had opportunity to intervene, rather than arriving too late to affect a better result.

Reportedly, in Liverpool (UK), it took 13 minutes from the first people observing the outbreak of fire to notifying the FRS; 21 minutes had passed before the FRS arrived and fire evolution in that time meant they could only fight the fire externally. For Stavanger (NO) there was 8 minutes before the FRS call and 19 minutes before their attendance. Those first minutes are invaluable, and this cannot be understated.

Whilst improved public awareness may result in some better outcomes, this is unreliable and cannot be expected. In both the aforementioned cases, the public safely evacuated themselves before raising an alarm and invaluable time was lost. Automatic detection thus seems essential.

There are numerous options for automatic detection. Generally, point-type smoke or heat detectors and multi-criteria detectors are used. In addition, linear heat cables can be used or, in the simplest case, a sprinkler head where heat causes an element to burst and the subsequent flow of water triggers an alarm.

Advances are being made in video fire and smoke detection too, but often this requires a level of visible light and might be prone to false alarms due to movements within the car park and may need newer technology beyond a simple software layer over the security CCTV in place. UV/IR detectors could also be considered.

Fundamentally the need for prompt alarm notifying the FRS is essential. Where their attendance time is likely to be longer than the time from alarm to second car involvement, then detection alone should be deemed inadequate.

6.4. Smoke Extraction

As car-to-car propagation results from radiated and convected heat, and the fire effluent of a burning vehicle recognised as noxious, there may be a case for automated exhaust. If so, this must be suitably rated for the likely temperatures of the smoke, and operation should not affect the automation of other systems.

Exhaust of the vented atmosphere must also not endanger other persons in proximity to discharge nor hinder the intervention of the FRS.

6.5. Automatic Fire Protection

The evidence strongly supports the need for automatic protection. Cooling the immediate area, through absorption of the emitted heat and wetting the adjacent area – cars and structure – is widely supported.

The body of research about the efficacy of deploying automatic sprinklers or water mist is growing. As too is whether this can be via individual heat operated bulb/links or if zonal deluge flooding is perhaps more effective and needed in some applications or specific areas.

Claims of successes using other technologies, such as encapsulating agents which are often proven only in small scale and on cylindrical cells - which is very different from the EV scenario - need thorough scrutiny.

6.6. Manual Fire Protection

Hose reels may assist the speed of intervention by the FRS. If a particular site has first-responders, they may use these, but need be duly trained, understand the risks associated, and should be provided with suitable PPE including Breathing Apparatus (BA) as fire effluent is toxic.

Portable fire extinguishers shall be installed per requirement and can be effective when used in a vehicular fire which as not become fully involved and is not a TR event. However, portable extinguishers are normally only intended to aid means of escape.

Manual call points, alarms triggered by human operation, are evidently worthwhile. For the two fires cited, had these been conveniently present and used, different outcomes might have resulted. Integration to an incident plan where perhaps a manual alarm automatically prompts CCTV operators to immediately investigate that location can also be considered, noting the alarm may be triggered along the persons' escape route and not necessarily proximate to the fire itself – which may cause delay whilst being verified or be incorrectly categorised as an unwanted/nuisance alarm also delaying positive action.

The above is not an exhaustive list of measures but identifies some that are practicable, possibly viable for retrofit and should be considered when stakeholders and experts engage in devising a site-specific protection strategy.

7. Fire Protection Solutions: Description and Characteristics

The fire protection solution to be implemented is directly dependent on the selected fire protection strategy, deduced from the risk analysis and regulation which may prescribe the highest level of protection. In addition, cost will often be a determining factor.

Before evaluating the different available strategies, it is important to keep in mind several general considerations:

- Fire detection can be used to trigger intervention, but itself will not have effect on the fire growth
- Water provides wetting and cooling, not just of the fire itself but of all combustibles proximate to the fire to delay or prevent involvement (e.g. from radiant heat)
- Automatic protection such as sprinklers or water mist should be preferred as they will promptly affect the fire development. They should be designed to curtail car-to-car fire spread
- The aim of effective fire protection is to limit vehicles involved, to a very small number, and to keep the situation manageable by a fire brigade, once they are on site

As seen before, charging areas have been identified as the highest risk areas in a garage. Irrespective of the type of vehicle, the risk with BEVs/PHEVs can increase during charging, so localized protection there seems more necessary.

A first approach is to focus on charging areas and to protect individually each car of each charging area. This can be done using water spray or water mist. This solution is especially relevant when the available water flow rate is a main constraint. If sufficient water flow is available, the discharge should also cover adjacent vehicles both sides of the burning car in order to deal with situations where propagation has already started or likely. When smoke development and flaring phenomena could lead to incorrect identification of the burning car, it can be beneficial to trigger the system with a very selective and precocious detection system. When conventional detection technologies such as smoke or temperature might be susceptible, then other solutions such as video fire detection could be considered alone or as complementary or supplementary.

A second approach is to focus on charging areas but to protect the whole charging area at the same time. A deluge system is implemented in this case using water or water mist. As pointed out before, wetting the adjacent cars and structure will play a decisive role to avoid domino effects. The required water flow rate is increased and dependent on the number of cars per charging area. Regarding fire detection, and without the need to identify which car has started to burn, a generic detection based on conventional detection technologies such as smoke, flame or temperature is relevant and can be easily implemented.

This approach is easy to be adapted to regular addition of charging areas in the garage, using the same water source. It is however essential not to increase the number of cars in each separated charging area to avoid a need to increase the required water and/or flow rate.

When the chosen strategy is to protect the entire surface of the garage, a sprinkler system or a water mist system using automatic nozzles should be implemented. As the detection is based on temperature increase at the ceiling level, the system triggering may not be precocious. Therefore, an additional electronic fire detection is advised to deliver an early alarm to evacuate people and initiate earlier FRS intervention, and manual call points can complement this philosophy.

In any case, the fire protection system design needs to be validated beforehand by a series of representative tests including tests with electrical vehicles. Very few test protocols are currently available. Specific protocols can be designed by third party laboratories to validate a system's performance. Tests results should be required by end users. Test protocols should pay a strong attention to battery types, fire reproducibility, etc. The validation of a solution should be based on its ability to achieve the following performance:

- to avoid propagation to adjacent cars
- to preserve structures
- to reduce ambient temperature and smoke to facilitate fire brigade intervention

8. Inspection, Testing and Maintenance

A holistic fire safety approach includes a strong Inspection, Testing, and Maintenance (ITM) program to ensure fire safety equipment is ready for emergencies.

A poorly maintained fire protection system can be as risky as not having one, increasing the chance of uncontrolled fire. A robust ITM program helps systems operate as designed during emergencies.

- **Fire detection**: Regular ITM for all detection and alarm components is essential for proper function. This includes cleaning, testing, calibration, and monitoring of dirt accumulation. Remote supervision helps detect faults early, and providers should comply with EN 16763.
- **Fire suppression**: Routine ITM should cover all suppression system components, accounting for any changes in building use or materials. I.e. regular inspection and maintenance are necessary for water reserves, valves, and sprinkler heads, following standards like EN 12845, which outline specific actions and frequencies for each system type.

9. Summary and Conclusions

Much work has already been undertaken, by recognised laboratories, authorities, and fire safety system manufacturers, and still continues to explore these issues. Not only pertaining to the existing fleet of vehicles but also the development of new powertrains, including different chemistries. Additionally non-EV developments prevail, such as hydrogen.

This guidance is thus not conclusive, and the reader need familiarize themselves with contemporary research and developments.

Both EVs and ICE vehicles have some inherent fire risks, but the nature of the risks is different between the two types of vehicles. Regardless of the type of drive, the fire load of modern vehicles is primarily determined by their size and weight, and by the amount of plastic used.

The ever-increasing size of today's vehicles with continuously rising fire loads pose a challenge for fire protection, especially in existing parking garages which were not originally planned and built for vehicles of this size and fire load. A result of which is vehicles being parked closer together, leading to a more rapid and extensive spread of fire, as examples from Stavanger (cause: defective ICE vehicle) and Luton (cause: defective ICE vehicle) show.

This means that fire protection measures must be adapted to prevent the spread of fire, regardless of the type of drive.

A site-specific risk analysis will assist in devising the required fire strategy.

- Prompt intervention is paramount to limit car-to-car spread. Very few cars need be involved before catastrophic loss results
- Automatic fire suppression, such as a water-based system, will mitigate the impact on the structure and afford more time from outbreak until the Fire and Rescue Service intervention
- Where prompt manual firefighting is provided, then an automatic system might need only comprise detection and alarm
- The actual requirements may be defined by local regulation, be this regional, state or national, or prescribed by a building owner, insurer or other stakeholders

10. Bibliography

- Guidance of Integrated Fire Protection Solutions for Lithium-ion Batteries. Euralarm, Feb 2022.
- Modern Vehicle Fire Hazards in Parking Garages and Vehicle Carriers. Combustion Science & Engineering, Inc. July 2020
- Sammanställning av bränder i elfordon och eltransportmedel år 2018–2023. Myndigheten för samhällsskydd och beredskap. MSB1647 – May 2024
- Fakten zum Thema Elektromobilität und Brandschutz. DEKRA Automobil GmbH. Stand 12.05.2022.
- Electrical Vehicle Fire Safety in Enclosed Spaces. RISE report 2023:42.
- Charging of Electrical Cars in Parking Garages. RISE report 2020:30.
- White Paper on Fire Safety in Parking Garages with Electrical Vehicles. 2023 Siemens
- Classification of Modern Vehicle Hazards in Parking Structures & Systems – Ph II. Combustion Science & Engineering, Inc. NFPA FPRF May 2024
- Kings Dock Car Park Fire – Protection Report. Merseyside Fire & Rescue Service. April 2018.
- Position paper on sprinkler systems in car parks containing electrical vehicles. EFSN. Nov 2023.
- Electric Vehicle Charging and Enclosed Car Parks v1. RSA. RCG033 12/2021.
- T0194 – Covered Car Parks – Fire Safety Guidance for Electric Vehicles. Office for Zero Emission Vehicles (OZEV) ARUP. Jul 2023.
- FR report of the CGEDD "The reinforcement of fire protection in covered car parks and the deployment of electric charging stations" July 2022
- ERP/PS guide of the DGSGCG "Practical guide relating to fire safety in covered car parks open to the public" January 2018
- CNPP white paper "electric batteries and mobility" June 2019
- Literature Review on Parking of Electric Vehicles. Report A1-02202.1 Jun 2023. NRC-CNRC.

Publication date: December 2024

Euralarm
Gubelstrasse 22
CH-6301 Zug (Switzerland)

Swiss Commercial Registration No: CHE-222.522.503

E secretariat@euralarm.org
W www.euralarm.org