WHITE PAPER

Fire safety in parking garages with electric vehicles

In collaboration with

Danfoss Fire Safety A/S

DBI FIRE AND SECURITY

SIEMENS

Disclaimer

Fire protection for electric vehicles in parking garages is a new application field for the fire safety industry. Related norms and standards are in preparation of under revision in most countries. Applications and solutions are, in general, still in development. The information given in this document is the current knowledge of the authors but should not be used instead of norms and without appropriate consultation.

The tests with the E-chargers, described in this document, were conducted for research purposes only and in no way indicate that E-chargers constitute a significant fire risk. E-charger manufacturers should be contacted in case of questions relating to applicability, certifications, or official product release.

Author**: Siemens Switzerland AG**

Siemens provides complete solutions for eMobility charging infrastructure, including software and high performing products. In the field of fire safety, Siemens is a leading, global supplier of products and systems, including detection, extinguishing, alarming, and evacuation. Over the past 5 years, Siemens has tested batteries of all the major battery manufacturers at its test laboratories, with particular focus on developing fire protection solutions for lithium-ion battery applications.

Author**: Danfoss Fire Safety A/S**

Danfoss Fire Safety A/S, an integral member of the Danfoss Group, is one of the pioneers in the high pressure water mist firefighting market. For decades, Danfoss has been developing, manufacturing, selling, installing, and servicing high pressure water mist systems under the brand name SEM-SAFE®. The development of the water mist fire suppression systems is documented through large- or full-scale fire testing.

Contributor**: Danish Institute of Fire and Security Technology (DBI)**

DBI is Denmark's leading knowledge center in the field of fire safety and security and is well recognized Internationally. Among other commercial and research activities, DBI performs ad hoc fire tests to assess the performance of systems and products with regards to specific fire hazards. Recently, DBI performed a series of research projects tackling fire safety of electric vehicles.

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1. Summary

Fire safety risks from batteries in electric vehicles

An electric vehicle (EV) battery fire releases the stored chemical energy, causing a rapid increase in temperature known as "thermal runaway". This results in an explosive combustion of the battery electrolyte vapor, with intense heat and highly toxic smoke, and can easily lead to multi-vehicle fires. There have been numerous such fires in electric bus and car parking garages, electric scooters, and electric vehicles on the open roads.

Purpose and scope of this document

The risk that the EV battery causes a fire is mitigated by intrinsic fire safety mechanisms (e.g., via battery design and by battery management systems). This document outlines how best to protect the garage buildings and their occupants after these intrinsic safety measures have failed. Specifically, we focus on early smoke detection and fire suppression.

Due to the special characteristics of EV battery fires, fire safety norms and standards are in development or revision. However, the optimization of EV fire safety continues to be a research topic.

In this document we present the authors current knowledge regarding how best to control EV garage fires. We describe the key elements of effective fire safety solutions for EVs and their charging infrastructure, as well as a proposal for fire protection targets and protection concepts.

The integration of fire safety systems into smart charging and building management systems is also considered.

Protection targets

The most important protection targets are as follows:

1. Minimize risk to garage occupants and fire service from heat and smoke.
2. Minimize the risk of compromising the structural integrity of the building, and
3. Minimize the time required to resume normal operation of the building following a fire.

Fire risk mitigation

This document covers recent investigations by Siemens and Danfoss, supported by the Danish Institute of Fire and Security Technology (DBI). These investigations indicate that high pressure water mist with open nozzles is highly effective: the water mist cools the surrounding environment, while thermal runaway and battery electrolyte off-gassing continue. Fire suppression should be triggered by fast detection using false alarm-free point detectors (Siemens **ASA***technology*). Based on this knowledge, we propose approaches to risk mitigation for EV fires and for the associated charging infrastructure, including product suggestions.

Norms and standards

The pace of change in eMobility is faster than the development of fire safety standards. Nevertheless, as the risks of fires in EV garages are now well understood, it is already possible provisionally to define some suitable protection targets and concepts, as described in this document.

At the time of writing, there are already several norms and standards, and others under development or revision, and the up-to-date details should be obtained from the relevant local authorities.

2. Introduction

In general, there are three types of garage: conventional garages, built without consideration of EVs; new-build garages, planned for cars with internal combustion engine (ICE) and EVs; and future garages, including smart charging infrastructure, and integrating renewable energy and intelligent interaction with the electricity supply grid (Fig. 1).

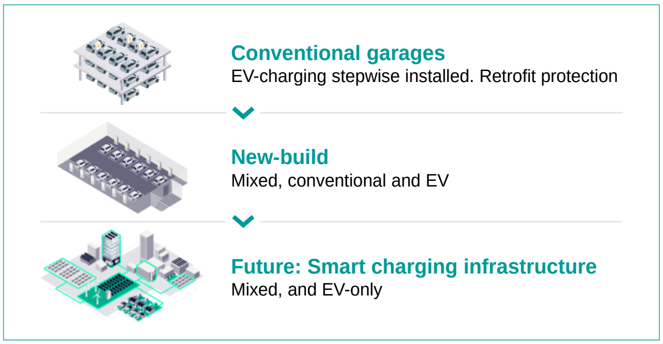

Figure 1: Types of parking garage

Today's garages mainly accommodate vehicles with internal combustion engines (ICE), together with a smaller number of EVs. As the proportion of EVs increases, the approach to fire safety in existing garages will be revisited. What form this fire protection should take, for existing as well as new garages, is a concern for fire safety consultants, civic authorities, fire services, facility managers, and insurance companies.

The most used battery in EVs is lithium-ion. These batteries present special fire safety hazards. Aging or damaged batteries can lead to an internal short circuit, causing an uncontrolled temperature increase known as thermal runaway. Once started, thermal runaway cannot be stopped and can lead to electrolyte vapor explosions and fintense fires.

There have been numerous eMobility fires caused by lithium-ion batteries in recent months, increasing the concerns of the public. Some city authorities and national governments are considering banning EVs from public parking facilities. Consequently, there is an urgent need for technical advice regarding fire safety solutions that can, as a minimum, prevent multi-vehicles fires and avoid severe damage to the associated buildings.

In future, EV charging will be a part of a city district or campus that includes renewable energy (e.g., solar panels), energy storage, smart buildings, and interaction with the smart grid (Fig. 2). All these elements, including vehicles, charging stations, and electrical equipment such as transformers and electrical energy buffer storage, will require fire protection.

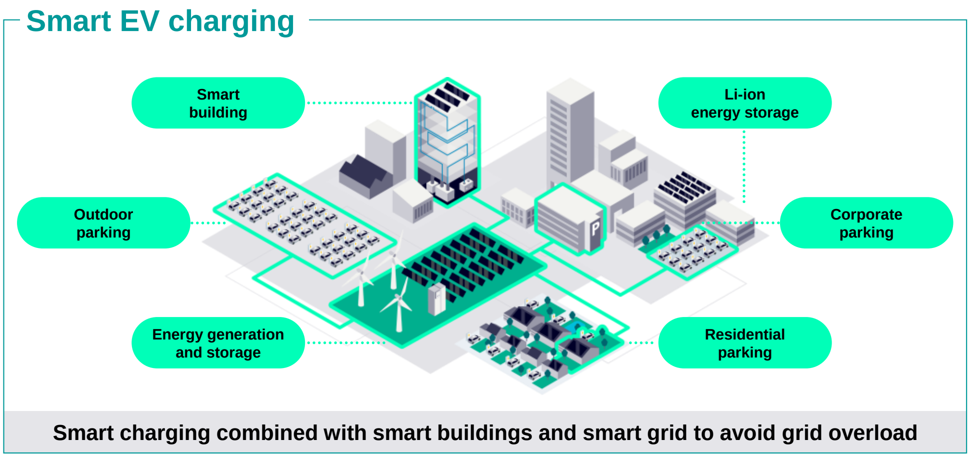

Figure 2: Smart charging infrastructure

EV charging infrastructure is also a potential cause of fire, given the ever-increasing power needed for faster charging. The early detection of fire in EVs and their charging infrastructure is technically straightforward, given a suitably designed fire safety system with fast detection and resistance to false alarms, as has been validated in recent tests (Refs 6, 10). Conversely, the question of which fire suppression technology to use has been more challenging.

3. Fire risks in EV parking garages

Multi-vehicle fires

For vehicles of all types, there is an increasing concern regarding the risk of multi-vehicle fires in parking garages. One example was the fire at Stavanger Airport in 2020 (Ref. 7), where a multi-vehicle fire destroyed more than 200 vehicles and caused the building partially to collapse. A similar case in Liverpool, UK (Ref. 14) resulted in the loss of 1400 vehicles as well as the destruction of the building.

Figure 3: Examples of garage fires

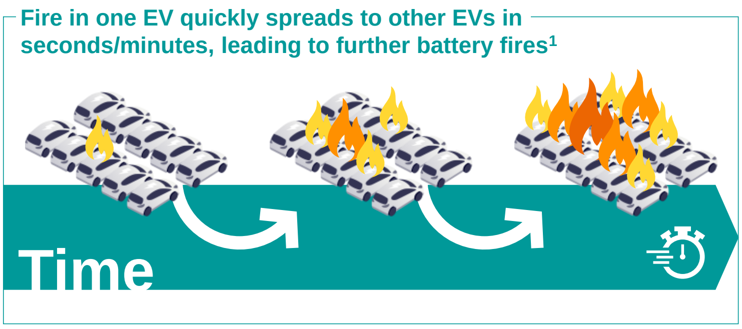

Figure 4: Fire quickly spreading from vehicle to vehicle

Various factors contribute to multi-vehicle fires: parking spaces are becoming smaller and the cars larger (more SUVs), facilitating the spread of fire from vehicle to vehicle in a chain reaction (Figure 4). Furthermore, the combustible plastic content of vehicles is now roughly 50% of the vehicle by volume[1] and, together with the tyres, forms most of the fire load.

[1] https://plasticmakers.org/our-solutions/sustainable-american-infrastructure/auto/

Electric vehicle fires

EV fires are comparable to ICE vehicle fires regarding fire load, fire intensity and smoke production. However, some characteristics of battery fires are different: They are difficult to extinguish and can unexpectedly reignite, hours, or days after all visible signs of fire are gone. This means that EV fires typically take longer to extinguish.

Fortunately, the risk that the battery itself causes a fire is mitigated by intrinsic fire safety mechanisms (e.g., via battery design and by battery management systems). If the intrinsic battery fire safety measures fail, and the battery starts to burn, the most effective option is to cool the battery. Due to the packaging of the car battery, and its location on the underside of the vehicle, it is not ideal to use a normal sprinkler system to cool the battery. When the battery fire occurs on the open road, some fire services use large, specially made water tanks (Figure 5). The burning vehicle is dropped into the tank where it stays for at least 24 hours.

Figure 5: Water cooling of vehicles with battery fires

Batteries in EVs pose a fire risk, not only if damaged in a collision, but also if there is damage to the battery separator due to a manufacturing error, or simply due to aging. Such defects can result in a short circuit in the battery, causing it to warm up. At temperatures above (circa) 70° C, the highly flammable electrolyte vapor starts to evaporate and, as the pressure increases, finally escapes from the battery cell in an event known as “off-gassing”. The temperature goes on increasing until the battery separator fails. This leads to a catastrophic temperature increase (“thermal runaway”) and an explosive combustion of the electrolyte gases if there is an ignition source (Figure 6).

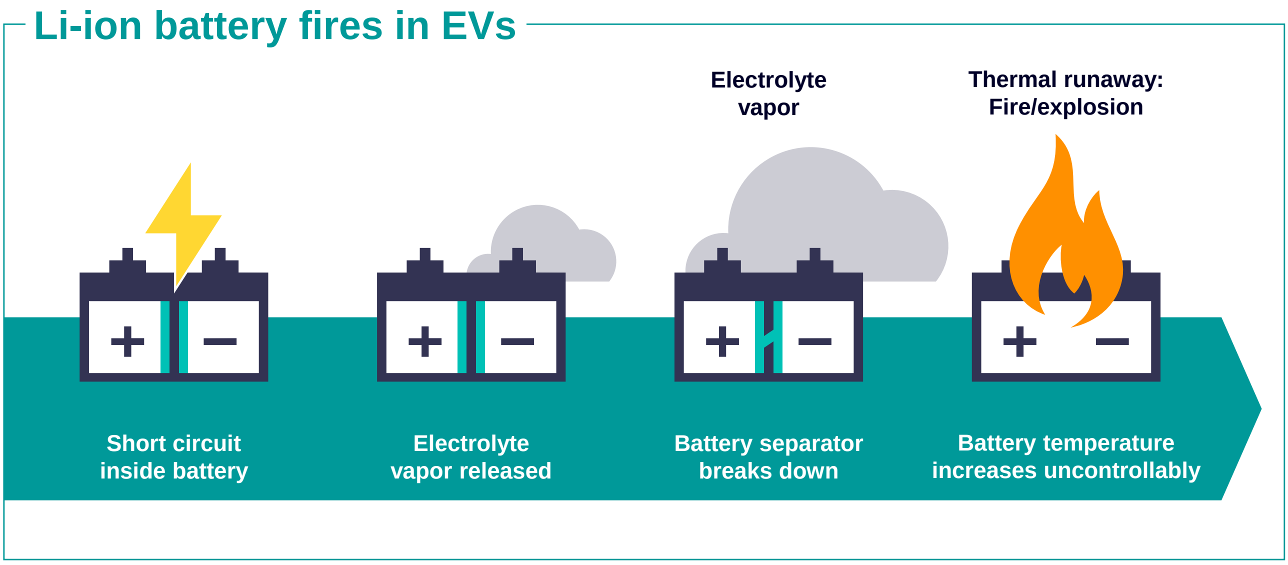

Figure 6: Development of thermal runaway

Charging stations

The extent of the risk of charging station fires is currently debatable. However, charging stations in any case have a lower fire load than motor vehicles and, so far, there are few recorded incidents. This situation may change as the number of charging stations increases, and as they start to age in service.

Figure 7: EV with charging station and charging cable

Fires in charging stations could result from electrical malfunctions and short circuits, damaged cables, faulty charging equipment or electrical surges, overheating of the charging equipment (e.g., due to charging the battery too quickly), improper use of the charging equipment, or lightning strikes.

Lithium-ion battery energy storage systems (BESS)

Given the need to charge EVs, manage the fluctuating supply of renewable energy, and balance the load on the electricity grid, we need an intelligent process to manage the grid supply, the local energy generation (solar PV), and the EV-charging power. A vital part of this solution is to install energy buffer storage, generally based on lithium-ion batteries placed on multiple racks, either in a dedicated room or as a containerized solution (Fig. 8).

The lithium-ion batteries in these installations also pose a risk of fire and explosive combustion resulting from thermal runaway of one or more lithium-ion batteries in the absence of adequate fire protection. (See Ref. 10.)

Figure 8: Battery energy storage room

Other electrical infrastructure

EV charging infrastructure will include standard electrical equipment (e.g., power transformers, power cables, etc.) that poses a potential fire risk. However, the relevant fire safety risks and protection concepts are well understood and not covered here.

Environmental and structural risks

Highly toxic smoke

Battery fires release heavy metals as fine dust, including cobalt, manganese, nickel, and lithium, threatening serious human health damage if inhaled. Heavy metal concentrations can easily exceed safe limits by factor >4000. This, together with smoke from burning plastics, floods the area with lethal smoke.

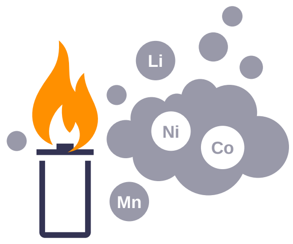

Figure 9: Toxic smoke with heavy metals

Environmental damage

The heavy metals released as fine dust and the electrolyte chemicals combine with extinguishing water making a highly toxic mixture which could pollute local groundwater. Consequently, it is important to manage the extinguishing wastewater to avoid environmental damage. Note: wastewater from extinguishing ICE vehicle fires is also highly toxic.

Structural considerations

Multi-vehicle fires result in very high temperatures that can lead to failure of reinforced concrete, steel supports, or other structural elements, potentially leading to building collapse (Ref. 7). Clearly, multi-vehicle fires must be prevented.

Engineering consultants and planners are confronted with various types of parking garage. Currently, the most common situation will be a garage with conventional vehicles, to which EVs and charging stations are added step by step. In such cases, it is necessary to review the fire safety provisions, for example the choice of fire suppression method.

A further case is new-build garages. Today, these are planned with an initial number of EV charging stations that will be extended in several phases over the coming years. To ensure cost efficiency and long-term fire risk minimization, it is important to plan how this phasing is best implemented, starting with the first design phase.

4. Protection targets

Protection targets for detection and suppression of fires in modern vehicles

We propose high-level fire protection targets as follows:

1. Minimize risk to garage occupants and fire service from heat and smoke.
2. Minimize the risk of compromising the structural integrity of the building; and
3. Minimize time required to resume normal operation of the building following a fire.

These targets are broken down into a more detailed proposal, as shown in the Appendix 1, Table 1.

Protection targets for alarming and evacuation

- Early alerting of all people at risk, safety officers and the fire brigade
- Early alerting of the facility manager, enabling fast, remedial reaction
- Preventing/avoiding false alarms

5. EV garage, fire detection and suppression testing

Detecting a fire in an EV is not a challenge, regardless of whether the source is the battery or some other electrical fault. There is a large quantity of smoke and virtually immediate detection is possible.

Beyond detection, further questions are as follows:

1. What fire suppression method should be used for EV battery fires, given the protection targets?
2. And what is the best way to detect fires in charging stations.

Consequently, two research projects were recently conducted: Siemens, Danfoss and DBI tested detection combined with high pressure water mist suppression (Ref. 6); and Siemens tested fire detection in charging stations (Ref. 9). These two projects are described below.

EV fire suppression tests with high pressure water mist, Denmark 2023

Motivation
As described in Section 3, when a battery goes into thermal runaway it is no longer possible to stop the fire – it can only be controlled until the fire service arrives. Standard water sprinklers are not ideal, as they require large volumes of water and have a minimal direct cooling effect on the battery. Consequently, Siemens and Danfoss, supported by the Danish Institute of Fire and Security Technology (DBI), conducted a series of tests to verify the effectiveness of early detection, combined with high pressure water mist for fire suppression.

Objective
The main objective of the investigation was to show the feasibility of using high pressure water mist, triggered by early detection, as an effective EV fire suppressant, allowing enough time for the fire service to arrive.

Test set-up
A simulated garage space was constructed from steel shipping containers (Fig. 10). The EVs under test were placed in the middle of the garage space, with a conventional ICE car on either side. Point-type smoke detectors and temperature sensors were placed in specific locations to enable assessment of fire detection and suppression performance targets. The details are given in a confidential report (Ref. 6).

The point detectors used were Siemens FDOOTC241 and FDOOT241. The high pressure water mist was a deluge system with open water mist nozzles.

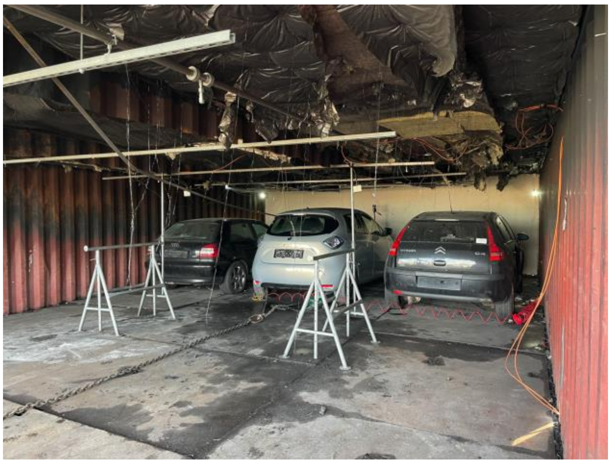

Figure 10: Vehicles in simulated garage space

Results
The tests resulted in intense fires and verified that, under these test conditions, detection with point detectors is fast and reliable. In addition, high pressure water mist performs well, allowing sufficient time for the fire service to arrive (typically 30 minutes), preventing multi-vehicle fires and avoiding the high temperatures that might lead to structural damage.

Figs. 11 and 12 show high pressure water mist protecting an adjacent vehicle, despite the intensity of the EV fire.

Figure 11: Various phases of Test 2, Ref. 6, showing an intense fire in the simulated garage space

Figure 12: Car adjacent to burnt EV, showing no damage after intense fire in Test 2, Ref. 6, with high pressure water mist fire suppression

Conclusions

1. The early fire detection system and high pressure water mist fulfilled the defined performance criteria.
2. High pressure water mist was an effective means of suppression, preventing multi-vehicle fires.
3. Further tests could explore a wider range of vehicles, battery types and (garage) infrastructural conditions.

Note: these tests (Ref. 6) are confidential to Siemens and Danfoss.

Smoke detection tests on EV charging stations, Munich 2022

Motivation

EV charging station fires are uncommon; however, this may change in the mid to long term. Firstly, the power of charging stations is increasing due the need for fast charging and, secondly, the risk of fire may increase as charging infrastructure ages.

Objective

Siemens made tests on a typical charging station, to verify the feasibility of very early detection of incipient fires with Siemens **ASA***technology* detectors and aspirating smoke detectors (ASD).

Test set-up

The test set-up included point detectors (ASA neural fire detector FDOOT241/FDOOTC241); and an ASD (FDA241) with air sampling pipe (Figure 13).

Siemens ASA detectors, and ASD, can detect the very early stages of a smoldering fire. Furthermore, they are specifically suitable for dirty environments, as they are specially designed to avoid false alarms due to vehicle exhaust gases or air pollution.

The point detectors and ASD sampling pipe were both placed on the upper, internal surface of the charging station (Fig. 13). The ASD sampling pipe was connected to an aspirating smoke detector, FDA241, positioned externally to the charging station.

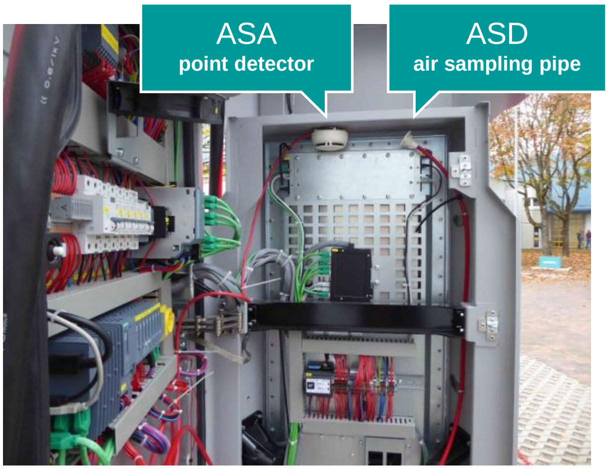

Figure 13: ASD pipe and ASA detector in charging station

A programmable hot-wire pyrolysis device was used to generate smoke to simulate an incipient electrical fire. The smoke was introduced into the charging station from below, via a hose through the ventilation slots.

Results

The test results showed that both the ASD and the ASA point detectors detected the fire very early, within 1 - 3 minutes of the activation of the simulated incipient fire. The ASD detector was circa 1 minute faster.

Conclusions

These results indicate that either detector would be effective. If there are multiple charging units in one location, it may be advantageous to use ASD for early detection, as one detector unit can sample the air in multiple charging stations, via one or more air sampling pipes. If there are only a few charging units, it may be more cost-effective to use ASA point detectors.

Early detection (with ASD or an ASA point detector) allows the facility manager to be alerted to an incipient charging station fire, enabling intervention such as shutting off the power to the charging station(s), manually or automatically, and extinguishing the fire with a portable fire extinguisher. An advantage of an ASA point detector over ASD is that the charging station which is the source of the fire can be automatically identified by the fire safety system and communicated immediately to the facility manager.

6. Protection concepts

Due to the significant fire load of the parked cars, an undetected and/or unsuppressed fire can easily become very difficult to manage and may even threaten the building structure. The fire protection system must guarantee rapid and reliable fire detection, activate the alarm devices and the relevant fire control installations, such as a high pressure water mist system, and support a timely evacuation.

In garages, exhaust emissions and air pollution can easily cause false alarms, leading to unnecessary evacuation and operational disruption. Consequently, it is necessary to install fire detectors which were developed especially for such harsh environments, and which respond robustly to deceptive phenomena.

Protection against fires originating in vehicles (EV and ICE)

Detection of EV fires

Siemens recommends smoke detectors with **ASA***technology* (e.g., Siemens point detectors FDOOTC241 or OOHC740) in garages with vehicles of all types.

These detectors are especially designed to avoid false alarms by distinguishing between smoke and deceptive phenomena, such as dust and air pollution. The detection parameters can be adjusted to take account of the dirty, polluted air found in a typical garage, and instead only detect real fires from EVs or conventional ICE vehicles.

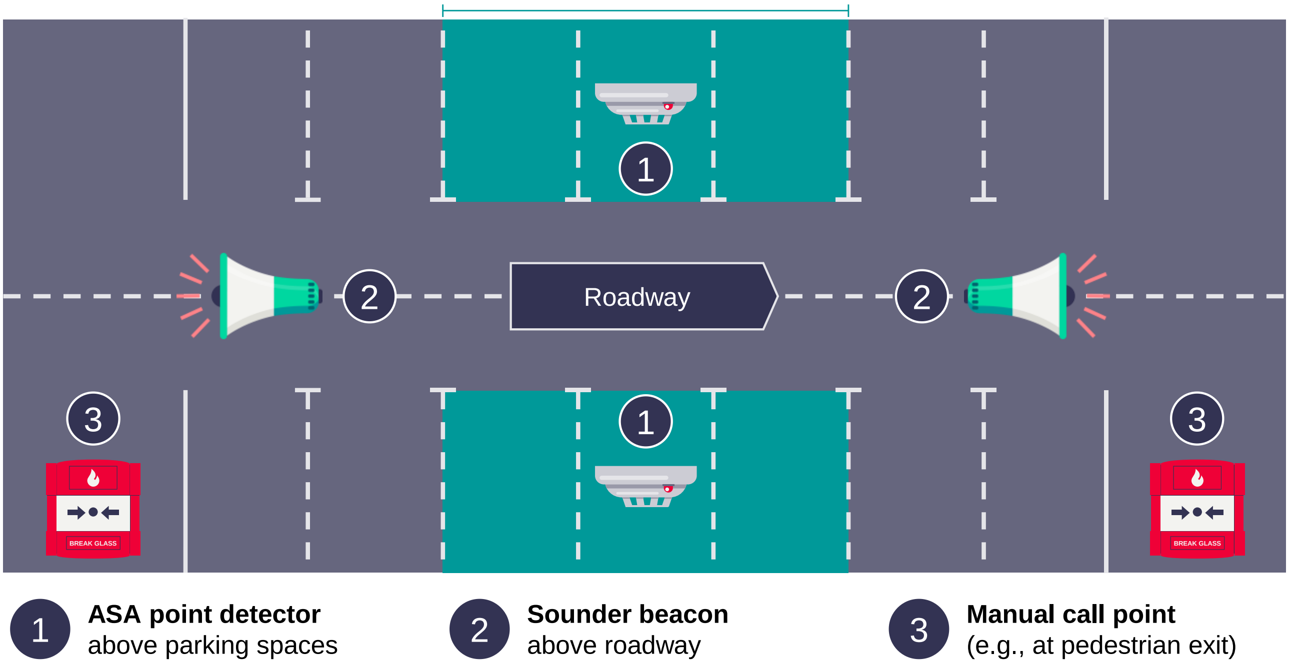

Figure 14: Positioning of detectors and sounders

For the earliest possible detection without false alarms, the fire detectors should be positioned above the parking spaces, not above the access lanes (see Figure 14.). Ventilation conditions must also be considered so that the smoke is not excessively diluted near the fire detectors. Manual call points are installed so that fire alarms can be triggered manually.

Suppression of EV fires

High pressure water mist

For centuries, water has been used to fight fires. Research and development resulted in the use of water as a firefighting medium for cooling the fire. As the fire increases the temperature of the water, energy is absorbed from the fire, resulting in a cooling effect. The breakthrough that high pressure water mist represents is to use the same method as traditional sprinklers, but to add the effect of converting the water into a mist (or fog).

In the SEM-SAFE® high pressure water mist system, clean water is forced by Danfoss high pressure water mist pumps through a stainless-steel piping network and specially engineered SEM-SAFE® nozzles, operating at 50 bar.

The very fine water droplets discharged by the SEM-SAFE® high pressure water mist system have an average size ranging from 50 to 100 µm. When the mist contacts the flames, the small droplets quickly evaporate, while expanding a minimum of 1,700 times, thus cooling the fire like a traditional sprinkler and simultaneously displacing the oxygen at the fire, like a gas-based suppression system.

The fine droplets are better suited for entering a shielded fire, such as that in the battery compartment of an EV. The water mist reaches the fire and flames due to the fine droplets that follow the air movement generated by the fire. The water mist cools the fire due to the droplets absorbing energy from the flames in the evaporation process.

High pressure water mist is an effective method for suppressing or extinguishing battery fires in EVs and preventing the fire from spreading to other vehicles. This is due to its ability to cool the battery cells and suppress the fire by interrupting the combustion chain reaction.

In summary, the advantages of high pressure water mist over traditional water sprinklers are as follows:

1. The combined cooling and oxygen displacement provide a cooling capacity up to 7 times greater than sprinklers.
2. The water consumption is reduced by up to 80% compared with traditional sprinklers.

Battery Fire suppression with piercing nozzle

The initial fire suppression with high pressure water mist or sprinklers, as described above, gives the fire service sufficient time to arrive and begin the process of longer-term suppression. For the EV batteries, one option is to direct a fire hose under the vehicle for an extended time. More recently, some fire services are using a pneumatically driven metal spike, sometimes referred to as a piercing nozzle, to punch a hole in the battery compartment. Water is then injected directly via a hose connected to the piercing nozzle. See Fig. 15.

Figure 15: Pneumatically driven, piercing nozzle

According to some estimates, this type of equipment could reduce the amount of extinguishing water needed to suppress a battery compartment fire by a factor 100.

Protection of EV charging stations

Point detectors located on the upper, inside surface of the charging station (Ref. 9), are shown to be effective in detecting fire in charging stations. We recommend Siemens point detectors based on **ASA***technology* (see Appendix 2), as they are specially designed to avoid false alarms in dirty environments such as garages.

The fire panel informs the facility manager of the fire location, enabling immediate action, e.g., with a hand-held extinguisher. Note: Appendix 3 addresses the integration of charging stations in an overall building management system.

To minimize fire risk, it is important for charging station operators and manufacturers to follow local standards and guidelines for electrical and fire safety, as well as conducting regular maintenance and inspections of the charging equipment, in addition to proper training of users and staff.

Alarming and evacuation

It is essential to alert all persons present in the vicinity, that a fire alarm has been activated. In Figure 14, sounder beacons are positioned on the ceiling above the centerline of the access lanes. The number and spacing of the devices will be determined by project-specific considerations (audibility and visibility), together with local codes of practice.

If local codes of practice require that a voice alarm system be installed, the underground garage will also be equipped with appropriately positioned and dimensioned loudspeakers. Such systems have the advantage of delivering clear voice messages even in acoustically challenging environments. People react more quickly and reliably to spoken messages than to audible or visual signals. This promotes the speed and efficiency of evacuation.

Appendix 1 – Fire protection targets and performance criteria

We propose high-level fire protection targets as follows:

1. Minimize the risk to garage occupants, and fire service, due to thermal radiation and smoke.
2. Minimize the risk of compromising the structural integrity of the building; and
3. Minimize time required to resume normal operation of the building following a fire.

These targets are broken down into a proposal for more detailed targets and performance criteria as shown below. For more details see Ref. 6.

	Fire protection targets	Performance criteria
1	Minimize threat to garage occupants	The temperature 5 m from ignition limited to ≤ 60°C, no later than 2 min after suppression activation and maintained for 10 mins thereafter (provisional target). The radiation 5 m from ignition ≤ 2.5 kW/m^2 at 1.8 m height, maintained for ≥10 mins after extinguishing activation. Note: these parameters are taken from Refs 3 and 4.
2	Minimize risk of compromising structural integrity of the building	No fire spread, or thermal damage, to vehicles adjacent to source vehicle. Temperature of steel structure, above the vehicle, shall not exceed 538°C. Note: 538°C is adopted from Ref. 2.
3	Fire suppression system shall be effective in mitigating fire hazard for at least 30 min after activation, allowing time for fire service to arrive.	Gas temperature on ceiling above fire source vehicle shall not exceed 315°C for at least 10ins after extinguishing activation, measured 76 mm below the ceiling at a radius of 1.8 m from ignition. Note: 315°C is adopted from Ref. 5. Water mist shall be delivered latest 60 s after smoke/electrolyte vapor detection and continue for at least 30 min. Minimum pressure during release 50 bar (±5%) at hydraulically most unfavorable positions.
4	Minimize the time for detecting smoke from the vehicle.	Detect smoke before a standard glass bulb sprinkler would operate.

Table 1: Detailed protection targets and performance criteria

Additionally, the following applies to underground garages:

- The garage must be fire-separated from the rest of the building.
- A large garage could be separated into fire compartments.
- It is recommended that it be equipped with the following:
  - a mechanical ventilation system for smoke extraction
  - a CO warning system.

Please refer to country-specific regulations, in accordance with local codes of practice.

Appendix 2 – Fire safety products

Point detectors

Point detectors with Siemens **ASA***technology* (Fig. 17) are specially designed to avoid false alarms in parking garages and other harsh environments. It is very important that ICE exhaust gases or other air pollution do not cause false alarms resulting in unnecessary extinguishing, evacuations, or call-out of the fire service.

For the protection of both ICE and EVs, we recommend Siemens point detectors, FDOOTC241 or OOHC740. These detectors come with Siemens false alarm guarantee. Siemens offers ASA detectors with Sinteso and Cerberus brands.

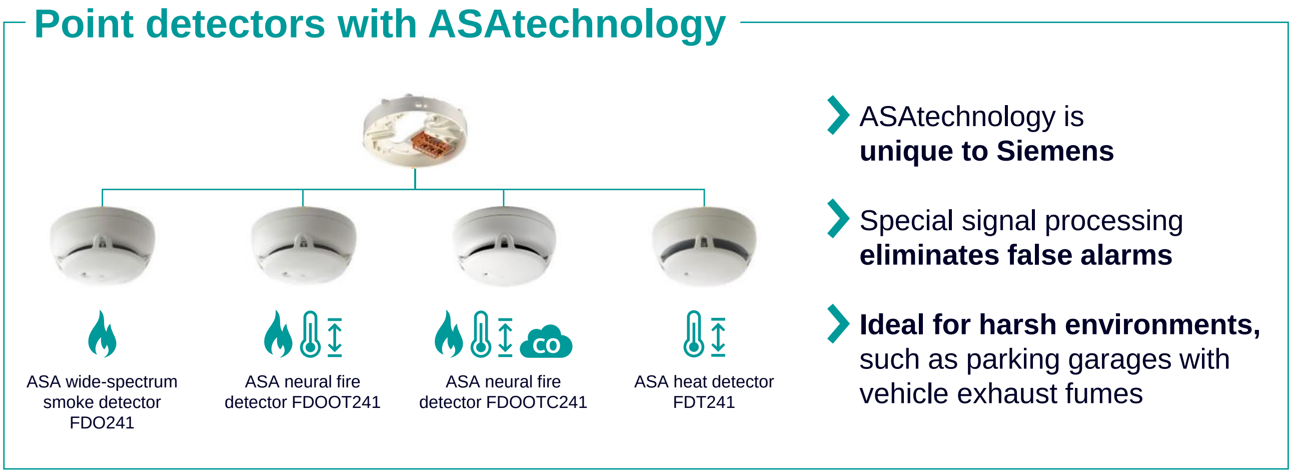

Figure 17: Siemens ASA detectors

Aspirating Smoke Detectors

Siemens ASD (Fig. 17) ensures very early fire detection in highly challenging applications. ASD continually draws air samples from multiple holes in a pipe network placed in the areas requiring protection and evaluates these samples for the presence of smoke. Siemens ASD is highly resistant to false alarms. The new ASD+ detectors cover an area of up to 6,700 m² making them suitable for small and very large areas. ASD detectors are integrated directly into Siemens fire safety systems.

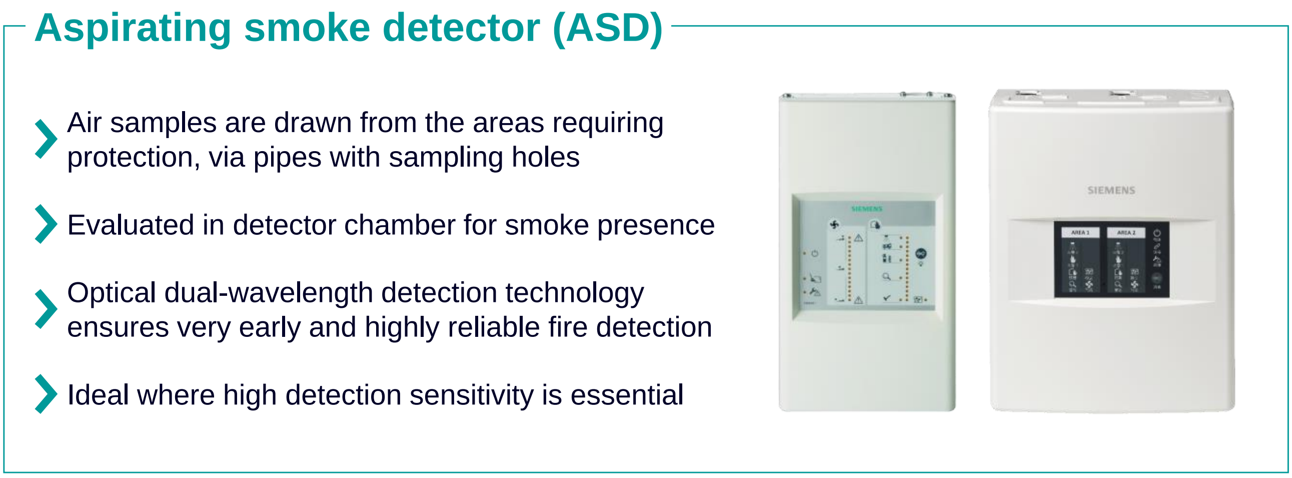

Figure 18: Siemens ASD detectors (FDA.)

Complete fire safety systems for buildings

Siemens offers a full range of fire safety systems for detection, extinguishing, alarming, and evacuation.

Danfoss high pressure water mist: SEM-SAFE®

SEM-SAFE® high pressure water mist is a unique fire-fighting system. By forcing water at a high pressure through nozzles, an extremely fine mist is created. Water is supplied via the SEM-SAFE® high pressure pump unit, which can supply all water mist applications. This is beneficial because only one unit serves all applications, and it is easy to add more sections and applications if needed. Servicing of only one unit is more cost-effective.

SEM-SAFE® water mist system with closed nozzles
On stand-by, the system maintains a pipe pressure of approx. 12 bar. When the temperature exceeds e.g., 57 °C, the heat-sensitive glass bulbs mounted in the nozzle heads melt. (Note: for EV garage application, the initial detection should be with a smoke detector, as this is faster than heat detection alone.) At this point, the high pressure pump is automatically activated, and water is forced through nozzles at high pressure (60 or 100 bar depending on nozzle type) to create a fine mist. Only nozzles with melted bulbs are activated. This means that only the heat-affected area will be actively sprayed.

SEM-SAFE® water mist system with open nozzles
On stand-by, the system has dry piping. This system activates manually or when sensors detect heat, smoke, or a flame, depending on type and application. The nozzles are grouped in sections and all the nozzles in the activated section will be released.

SEM-SAFE® water mist system in operation
During operation, the high pressure pump draws water from the pump unit *with tank* (a non-pressurized stainless-steel tank) and forces it through a non-return valve to a high pressure manifold. From here, it is distributed to the relevant section(s) via the section valve. A pressure relief valve controls the pump pressure and is designed to return the full pump capacity to the pump unit *with tank*.

Features and benefits

Quick firefighting

- As water mist both cools the fire and removes oxygen, firefighting is faster.
- Due to the cooling effect of water mist, re-ignition is avoided.
- The SEM-SAFE® water mist system is ready for re-use immediately after a fire.

Less damage

- The low water consumption of high pressure water mist minimizes water damage.
- The SEM-SAFE® system can be deployed instantly, resulting in less damage.
- Using only pure water, the SEM-SAFE® water mist system offers the best possible protection of equipment and human lives.

Reduced downtime

- Reduced damage often means less down time, resulting in much lower costs.
- Cylinder refill is not needed, saving expensive refilling time and overall costs.

Appendix 3 – Integration into smart building management

Fire protection in future garages with smart charging will be part of a more general smart building management system. In the example shown in Fig.19, a fire in an EV charging station is detected, alerting the fire control system, which calls the emergency services, and notifies the facility manager, as well as initiating evacuation and extinguishing.

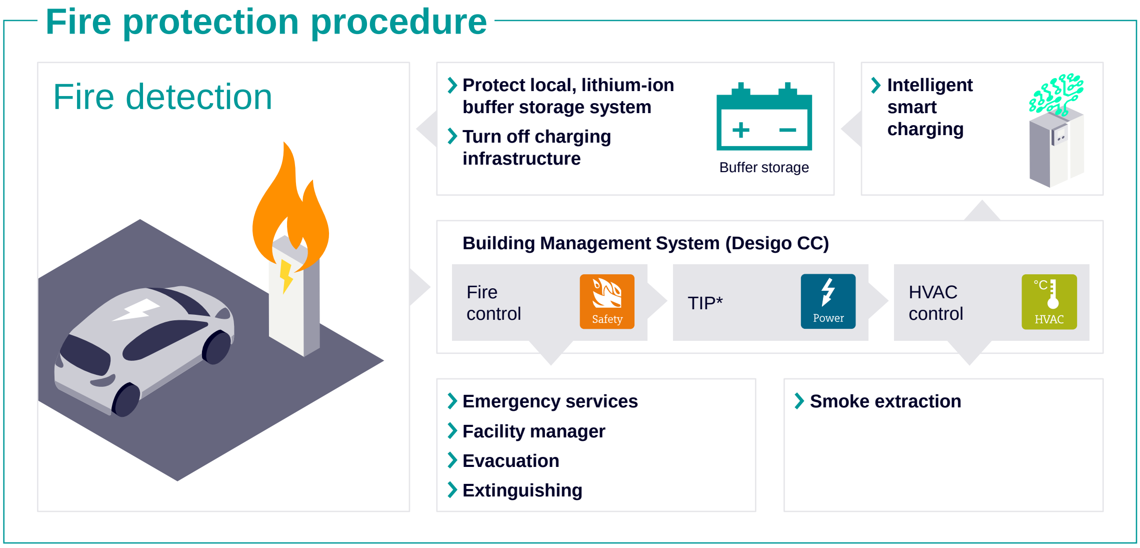

Figure 19: Integration of fire detection in smart building

The fire safety system also interacts with the totally integrated power (TIP) subsystem which sends a signal to turn off the buffer storage system and the affected EV charging stations. Similarly, a signal is sent to the HVAC system to switch off the normal ventilation and switch on the smoke extraction.

EV fire safety is an integral part of an overall building management system (Figure 16), based on Desigo CC (in future, Building X platform). In this way, the facility manager is able remotely to monitor and operate the EV charging infrastructure in addition to building security, access, power management, fire safety, lighting, and climate control.

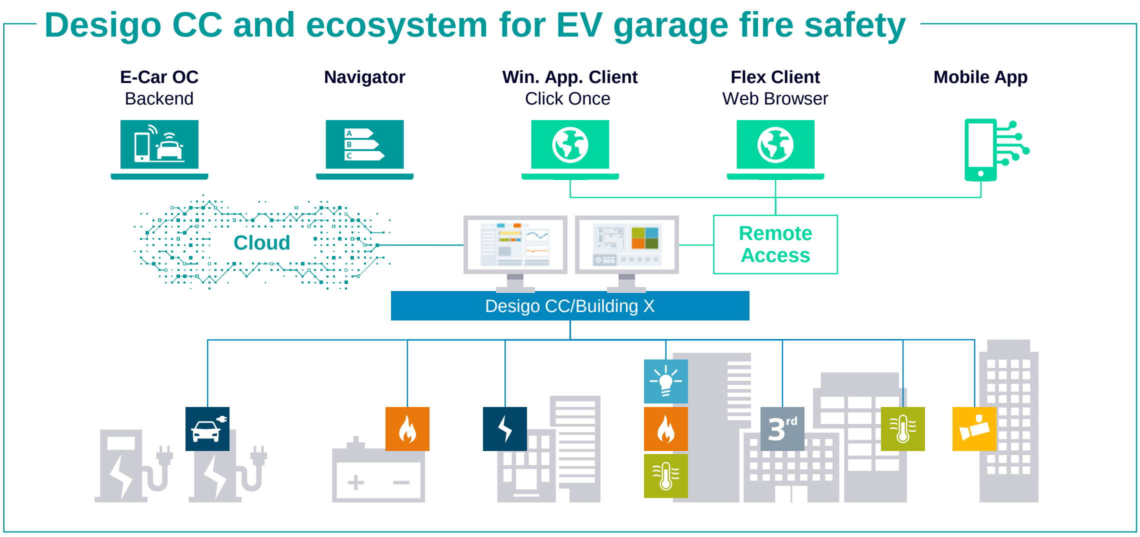

Figure 16: Integration of fire safety in building management system

Appendix 4 – Further application details

The following table gives more details regarding detection and alarming devices.

Device type	Comments
Automatic fire detectors ASA neural fire and CO detectors	Early detection of all types of fire and robust behavior toward deceptive phenomena (exhaust emissions). Monitoring of the CO concentration. • For fire detection: Parameter set with balanced behavior • For CO monitoring: Parameter set with robust behavior • IP protection of at least IP43 If an autonomous CO If an autonomous CO warning system has been installed, ASA neural fire detectors without CO sensors can be used.
Manual call points MCPs	**Manual call points:** • Single or double action (depending on local regulations) • IP protection of at least IP43 (for operation in a harsh environment
Warning devices Sounder beacons	**Optimal visual and acoustic warning to garage occupants:** • Ceiling-mounting requires a sounder-beacon base with a blanking plate • Beacons may be white or red LEDs, depending on local regulations or project-specific considerations
Positioning of system elements (Figure 14)	**Automatic fire detectors:** • On the ceiling, above the parking spaces • At least 0.5 m from the wall • Away from the airflow of the ventilation system **Manual call points:** • Next to the exits and entrances • At a height of 1.4 m ± 0.2 m **Sounder beacons:** • On the ceiling, along the access lanes • The distance between neighboring devices will be determined by local codes of practice and project-specific considerations
Related measures	
• Fire extinguisher (powder extinguisher for Fire Categories A, B and C) • Wall hydrant or sprinkler system • Public Address & Evacuation System, including speakers and central control unit (rack or compact)	

Table 2: Application details

Further considerations

The following applies to all enclosed parking garages:

- There must be at least two well sign-posted escape routes.
- The garage must have emergency lighting.
- Portable fire extinguishers must be provided.
- No flammable materials such as gasoline, oil, gas bottles, chemicals, wood, cardboard boxes, etc. may be stored there.

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Glossary

ASA (**ASA***technology*)	Siemens detection technology for eliminating false alarms
ASD	Aspirating Smoke Detector
BESS	Battery Energy Storage System
EV	Electric Vehicle (car/automobile, in this document)
eMobility	Use of electric propulsion for a wide range of transportation types
ICE	Internal Combustion Engine (conventional automobile)
Off-gassing	Release of electrolyte vapor from a battery at elevated temperature
Thermal runaway	Uncontrolled temperature increase of a burning battery
TIP	Totally Integrated Power
HVAC	Heating, Ventilation and Air Conditioning

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