



## Why Fires in Parking Garages Present a Multi-Level Risk

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Fires in parking garages/lots and the millions of dollars of damage they inflict on buildings, vehicles, and the environment are frequently reported in the press. Recent examples include the fires in parking garages at Stavanger Airport, Norway<sup>1</sup> (7 January 2020) and Münster-Osnabrück Airport, Germany<sup>2</sup> (14 October 2019), respectively, plus the large XXL garage complex in Dorsten, Germany, which burned in March of this year<sup>3</sup>. A quick trawl of the internet reveals just how frequently such incidents occur.

A common characteristic found in damage reports is the rapid spread of fire in garages that do not have effective fire protection measures. Such precautions ensure that an incipient fire is detected quickly, that efforts to fight the emerging fire can begin asap, and that the spread of fire to neighboring vehicles is prevented.

In the absence of automatic fire detection and firefighting systems, an attending fire department can quickly reach the limits of their extinguishing capabilities, meaning that the fire and its effects, including smoke, are more likely to spread rapidly.

This article discusses the specific hazard exposure of parking garages, possible fire protection measures, and advice for underwriters within the framework of fire insurance. For context, we are referring only to medium and large-sized parking garages. Exhibition, sales, factory, and storage areas for motor vehicles are not considered garages for this article's purposes.

### Parking garage design

Parking garage buildings can be either independent, free-standing structures or an integral part of larger buildings, such as apartment or office complexes.

They can be single or multi-story (including high-rise), have several basement levels, or consist only of basement levels (underground garages). In terms of construction,

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### About This Newsletter

Created for our clients, our Property Matters publication provides an in-depth look at timely and important topics affecting commercial and personal lines of property insurance.

they can be open-air structures without exterior walls or completely enclosed. Garages can be public or private facilities accessible only to a limited group, such as the residents of a residential complex.

“Automated” garages are becoming increasingly common. These buildings are predominantly present where space is in short supply, such as in inner cities. They allow many cars to be parked in a relatively small area using a racking design. The cars are stacked very close to each other vertically and horizontally, thereby making the best use of the available space.

### Fire causes and behaviour

By their nature, parking garages form horizontal and vertical open shafts that allow and promote fire spread. A free-standing garage has the advantage that if a fire occurs, it (and the associated smoke and heat) does not spread so easily to other buildings.

However, in the case of garage systems that are part of larger buildings, fire, smoke, and combustion by-products enter parts of the building above the garage through hollow cavities, elevator shafts, stairwells, and utility areas more easily. This creates a significant safety hazard and greater potential for damage. Fires in parking garages can damage the entire building’s structure to such an extent that the building’s structural integrity is compromised, posing a risk of collapse.

The causes of fires in parking garages are many and varied, including:

- Technical defects in parked vehicles
- Ignition of flammable materials during maintenance and servicing work
- Disregard of smoking bans
- Electrical faults (e.g., short circuits, damage to electrical cables and lines)
- Arson
- Fuels (e.g., gasoline, diesel) present in vehicles
- Batteries present in e-vehicles

Modern cars increasingly utilize combustible materials.<sup>4</sup> This is, in part, prompted by the increasingly stringent legal regulations on fuel efficiency and vehicle safety. By replacing metal parts with light metals, plastics (e.g., aluminum, carbon fiber or plastic body parts, plastic cockpits, plastics and foams used for interior trim), and textiles, vehicles

have been made lighter, safer, more rust-resistant, and less expensive. At the same time, this has increased the fire load significantly.

Modern vehicles also increasingly incorporate electronics and plastic wiring, creating additional potential ignition sources, which further increases the fire load.

Together, these factors can contribute to the rapid acceleration of a fire reaching up to 1000 degrees Celsius and producing massive amounts of dense and toxic smoke.

Vehicles parked closely together promote the rapid spread of fire, and in closed parking garages, cause the formation of a flashover situation, which makes it difficult for the fire department to combat the fire effectively. Due to the high temperatures, oil and fuel tanks (largely made of plastic) can melt and release their contents - literally adding further fuel to the fire. Reduced visibility caused by smoke can significantly impede firefighters’ efforts and lead to extensive damage to buildings and vehicles.

Initial findings do not indicate that e-vehicles are more likely to cause damage than conventional motor vehicles.<sup>5</sup> Still, in the event of a fire, problems arise due to the different fire characteristics of the lithium-ion batteries that supply the drive energy for these vehicles.

For example, due to the high voltage of 600 to 800 volts with a very high energy density, defective batteries can cause a self-sustaining fire with “thermal run-away”. In addition, they can produce highly toxic gases such as hydrofluoric acid. Lithium-ion batteries also require a concerted and lengthy firefighting effort to cool them down. As there is a risk that the fire could reignite if the cooling of the burning battery is interrupted, such fires require large amounts of water. Other extinguishing agents such as gel, sand, or special foam can be used to stop the fire from spreading quickly to other vehicles – a distinct possibility given the high temperatures involved in a battery fire.

As touched upon, automated parking garages are particularly vulnerable to fire hazards compared with conventional parking buildings given their densely packed layout (similar to high-bay warehouses),<sup>6</sup> reducing the time between the outbreak of a fire and the onset of a flashover situation. Also, limited access and dense smoke generation hamper firefighters’ options. In this way, these fires are often compared with shelf-storage fires. If an existing sprinkler system or the fire department does not succeed in controlling a developing fire, the thermal stress on building components can lead to a loss of the supporting structure.

Other hazards can result from the roof surfaces of parking buildings, which are increasingly equipped with photovoltaic systems. Photovoltaic panels are made of combustible material, making them a potential ignition source and making firefighting attempts more difficult.

Fighting a vehicle fire in a garage, especially underground, presents considerable risk and danger to a fire department's emergency services. Regardless of the type of engine used to power the burning vehicle(s), such fires are challenging.

### Trends and statistics

As yet, there are no global statistics on the probability of parking garage fires and the extent of damage to be expected. Therefore, it remains difficult to judge exactly how the increasing use of plastics in vehicle production and the growing number of automated parking garages affect the frequency and intensity of garage fires.

Figures from the U.S. show an annual average of 1,858 fires in commercial parking garages between 2014 and 2018, with an average annual property damage cost of USD 22.8 million.<sup>7</sup> In 2018, a total of 212,500 vehicle fires occurred, 16% of which occurred in parking areas.<sup>8</sup> Unfortunately, a more comprehensive statement is not available.

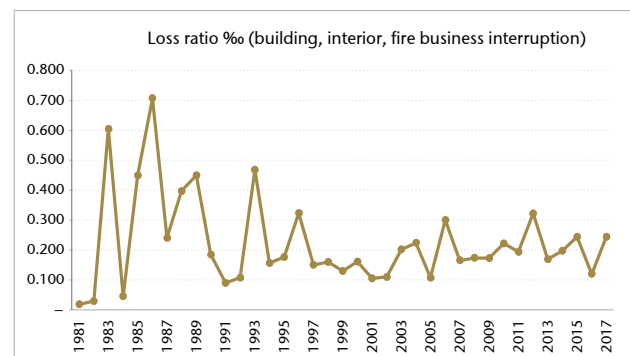
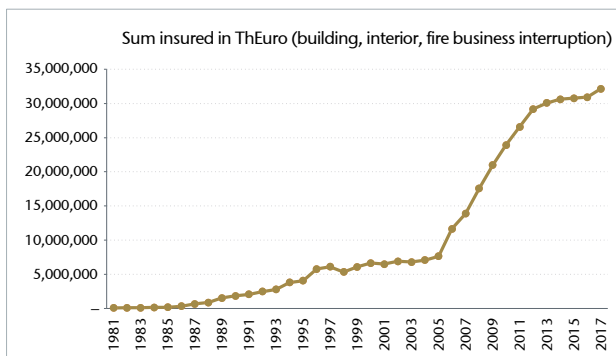
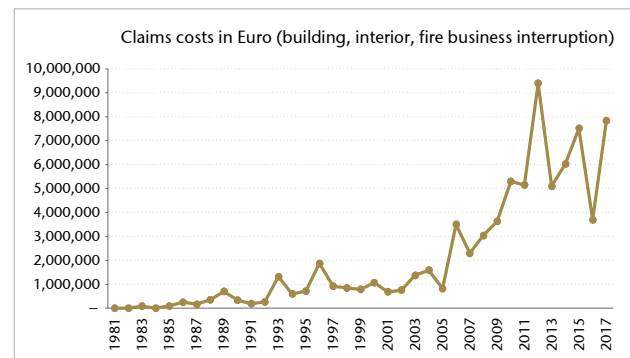
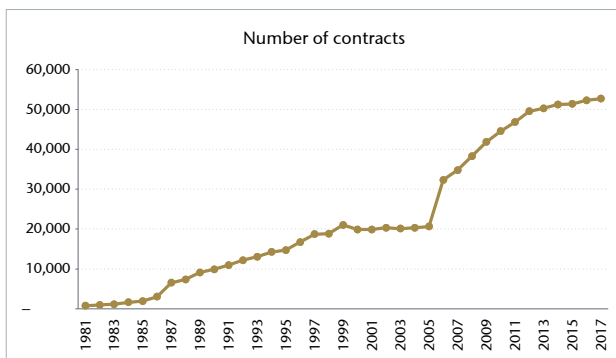
A study from 2015 by four French researchers examined the development of parking garage fires, comparing several hundred French parking garage fires between 1995 and 1997 with those occurring between 2010 and 2014.<sup>9</sup>

In the garage fires between 1995 and 1997, 98% involved fewer than four vehicles; only 1% of the fires involved more than five vehicles, and none of the fires studied involved more than seven vehicles. In contrast, 8% of fires between 2010 and 2014 involved more than five vehicles, and 6% involved more than seven vehicles. The authors concluded that a typical garage fire today is more likely to involve multiple vehicles than it did 20 years ago. Thus, the fire risk in parking garages has increased significantly over the past 20 years.

According to the German Association of Technical Fire Protection (bvfa), there were 42 fires in garages in Germany in 2016, with 60 injuries and high property damage.<sup>10</sup> While reliable figures on fires in parking garages are hard to come by, some statistical data has been collated by the German Insurance Association (GDV, Berlin), as summarized below.

The figures show that insurance policy numbers, sums insured, and claims expenditure have all increased significantly in recent decades. Particularly worth

### Cumulative number of policies, claims expenditure, sum insured, and claims rates for property and fire business interruption insurance of parking garages from 1981 to 2017.



Source: GDV risk statistics (not published) and own calculations.

mentioning is that, as before, the insured sums and claims for parking garages and garages essentially stem from building insurance; other policies and thus the insured sums and resulting claims sums are subordinate.

In comparison, loss rates have fallen slightly over the years, undoubtedly due to the sharp increase in sums insured. But given known events post-2017, we expect the loss rates to increase in the coming years. It's also likely that the figures didn't include all parking garage damages due to the buildings being co-insured as part of a larger contract and, therefore, not included in the statistics.



## Fire protection measures

There are many variables involved in fighting a motor vehicle fire in a parking garage, including garage structure, access, elevation changes, confined spaces (or areas where heat and smoke are trapped), exposure, and fire department response.

This gives rise to the question of whether current building fire codes for parking garages are still adequate, given how dramatically vehicle fire loads have changed in recent decades. Further questions also arise regarding how newer design and layout trends in urban garages (especially automated parking garages) change the hazard situation and what protective measures are appropriate.

A primary goal for the near future should be to quantify the fire hazard presented by modern vehicles so the findings can be used to determine the optimal design of different parking garages and the necessary fire protection concepts.

Globally, many countries (including, for example, Spain and Germany) have building and fire codes that require parking garage operators to install sprinkler systems by law. In some German states, such as Baden-Württemberg and Hesse, mechanical smoke and heat exhaust ventilation systems (SHEVS) have been considered alternatives to sprinkler systems for some time. However, the result of discussions at a recent fire protection forum was that sprinkler systems are indispensable in parking garages and should not be replaced by smoke and heat extraction systems.<sup>11</sup>

Nevertheless, such systems can help keep attack routes clear of smoke for firefighters. Tests of SHEVS using jet ventilators proved effective in quickly removing smoke from garages, even if they did not contain or extinguish the fire itself.

When using SHEVS, one must take care that smoke is channeled in the proper direction, that the horizontal jet ventilation systems do not move more air or smoke through the space than can be released to the outside, or supply air to the inside through the exhaust shafts. Also, the effects of SHEVS on water extinguishing systems must be considered to ensure that the air and heat flow generated do not complicate the triggering and effectiveness of sprinkler systems.

Automatic fire extinguishing systems (e.g., sprinkler systems or automatic water spray extinguishing systems) have proven particularly useful for automatic parking garages, where the dense horizontal and vertical packing of vehicles over several levels makes it very difficult for the fire department to extinguish the fire. In some cases, installing an additional automatic foam system to extinguish any burning liquids, such as fuel (which may be released), is recommended to reduce the risk of re-ignition.

To limit the spread of fire, parking garages that are part of a larger building should be divided into separate fire compartments; larger parking garages should be divided into several fire compartments by internal firewalls. Passageways and openings in fire-resistant walls and ceilings, should always be fire-resistant to limit the spread of fire and smoke. As a general rule, the use of combustible building materials and construction materials in garages and parking garages should be avoided, as they increase the fire load.

The formation of smoke compartments and the installation of smoke extraction systems within fire compartments can limit the rapid spread of smoke to the entire facility in the event of a fire, thus enabling the fire department to carry out an effective firefighting attack.

To ensure that fire brigades are quickly alerted, larger garages should be equipped with an automatic fire alarm system. Such systems must be planned and installed according to the situation to prevent rapid soiling of the detectors, e.g., by exhaust fumes, dust, and vandalism. While closed underground garages have high dust loads to contend with, open elevated garages are exposed to weather-related influences such as temperature fluctuations.

## Guidance for underwriters

Parking garages used to be considered low-loss risks, both in terms of loss occurrence probability and loss amount. However, there are indications that changes to their design and the materials used to construct modern vehicles are worsening their risk and loss potential.

Many garage facilities that are still used today were built in accordance with the building regulations of the time and no longer meet the changed exposure from the point of view of fire protection. Therefore, it is advisable to consider some additional aspects when assessing them:

### Insurance contract

The contract should clearly outline the scope of coverage (e.g., what's covered? Building, equipment, and business interruption?). It should also clarify whether there is co-cover for the parked vehicles or whether the vehicles are insured under existing motor vehicle insurance policies in the event of a claim. And it should detail the extent to which liability aspects are also insured. Furthermore, which hazardous events are covered should also be clear (e.g., named perils? Flexa, all perils, natural perils?).

### Insured value

In the event of a claim, it's often the case that the insured values are insufficient. Therefore, it is advisable to check the reported insured values and make sure that they are regularly adjusted when renewing the insurance policy. Any agreed initial risk positions should be taken into account when underwriting and calculating the insurance premium.

### Clauses

Pay attention to the additional terms and clauses agreed in the insurance contract to rule out the possibility of surprising circumstances being covered beyond the expectations of a conventional property insurance contract.

In addition to the more insurance-related considerations, one should consider the given risk situation of the parking garage. This includes, but is not limited to:

- Type of garage (e.g., stand-alone, part of a larger building, open construction, enclosed construction, underground, above ground, number of stories)
- Type of construction (e.g., conventional garage, automated facility, racking facility)
- Type of construction (e.g., materials and components used)
- Existing fire protection measures:
  - > Technical measures
    - ◇ Automatic or manual firefighting system (e.g., sprinkler, water spray extinguishing system)
    - ◇ Installation of an automatic fire detection system and type of alarm, guarding, presence of operating personnel
  - ◇ Existing hydrant system as well as further extinguishing water extraction possibilities, wall hydrants
  - ◇ Existing initial firefighting equipment (e.g., fire extinguishers)
  - ◇ Existing smoke extraction system
- > Structural measures:
  - ◇ Separation of the garage from surrounding structures by spatial distance or effective structural fire protection separators (e.g., firewalls)
  - ◇ Housing of technical equipment in separate fire-resistant rooms (e.g., electrical equipment rooms, boiler rooms)
  - ◇ Adequate sealing of openings in horizontal and vertical structural ceilings and walls that affect fire protection (e.g., electrical, heating and ventilation systems) and checks of whether appropriate measures have been taken to prevent heat and smoke from being passed on to ventilation systems.
- > Organizational measures:
  - ◇ Order and cleanliness
  - ◇ Regular revisions of existing fire protection measures and elimination of detected defects (e.g., sprinkler system)
  - ◇ Regular maintenance and servicing of technical systems (e.g., electrical systems, heating systems)
  - ◇ Smoking ban in place, as well as welding permit procedure
  - ◇ Storage of flammable materials in the garage area prohibited
  - ◇ Existing rescue and escape routes kept clear
- > Fire prevention
  - ◇ Responsible fire department capability (e.g., voluntary or professional, their distance from the parking garage, their local knowledge, equipment and facilities, ability to fight fires involving flammable liquids, batteries)
  - ◇ Existing extinguishing water facilities on-site (e.g., hydrants, extinguishing water tapping points)
  - ◇ Firefighting areas and possible internal access routes for the fire department.
- Damage history: Type and amount of any past damage cases.
- Insurance accumulation: Other existing insurance policies (e.g., other building, business interruption, motor vehicle liability insurance), interactions and repercussions, use and operation of a property (e.g., airports, retail outlets, offices, and apartment buildings).



In the U.S., the standard *NFPA 88A-2019: Standard for Parking Structures* has recently been revised.<sup>12</sup> It provides information on the construction, protection, and control of hazards in open and enclosed parking structures and presents a good starting point. Depending on the state, there are also different legal and building code guidelines and regulations that must be observed.

For now, sprinkler systems remain the primary protection measure against fires in parking garages, helping to extinguish fires and/or contain them until firefighters arrive. Other traditional fire protection measures for parking garages include:

- Using non-combustible building materials for constructing the buildings and the technical systems, such as ventilation systems.
- Choosing non-combustible materials for cladding and insulation layers under ceilings and roofs.
- Placing technical operating rooms and equipment in separate fire-resistant rooms
- Ensuring any openings in fire-resistant partitions (both horizontal and vertical) are fire-resistant and that no fire transmission is possible via the ventilation system into adjacent fire compartments (e.g., by installing fire-resistant fire dampers).
- Protecting electrical systems and wiring as well as pipelines from fire.
- Ensuring adherence to organizational fire protection measures such as general orderliness and cleanliness, not storing flammable materials in the garage, no smoking, granting welding permits for maintenance and repair work, etc.
- Making sure firefighting equipment to combat the outbreak of a fire is available, e.g., wall hydrants, fire extinguishers, risers with feed options for the fire department, plus secured rescue and escape routes that also serve as attack routes for the fire department.
- Providing access routes for firefighters, as well as the installation of an adequate supply of extinguishing water.

## Summary

Fires in parking garages are becoming an increasingly common and costly problem. While there are multiple reasons, there are two primary drivers. The first is the increasing use of combustible materials in modern vehicle construction. This is coupled with greater use of

electronic equipment, increasing the number of potential ignition sources.

The second key factor lies in the design of parking garages themselves. Existing parking garages are often constructed and operated under old building code regulations that do not take the changing risk potential of modern vehicles into account. Meanwhile, newer and more effective parking concepts, such as automated rack parking garages, present their own challenges.



These factors have been behind several recent major fire damage incidents, with losses running into the millions. Supplementary fire protection measures could improve the damage situation. For example, installing an adequate sprinkler system is an effective way to fight developing fires, enabling rapid extinguishing and limiting the eventual damage.

In this respect, property insurers would be well advised to pay close attention during the underwriting process to make appropriate decisions and to calculate an adequate insurance premium based on the scope of coverage required in each case.

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